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THE REINDEER INDUSTRY AND THE CANADIAN ESKIMO: *A paper read at the Evening Meeting of the Society on 17 February 1936 by*

ERLING PORSILD

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WITH the arrival in March 1935 at Kittigazuit, on the east bank of the Mackenzie river, North-West Territories, Canada, of a herd of 2370 domesticated reindeer, the final stage of a remarkable instance of transportation of animals had been completed. The trek of this herd, which in newspaper and magazine articles has been referred to as "The Canadian Drive," started from the Napaktolik mountains in the Kotzebue Sound region in Alaska in December 1929, and the herd thus took over five years to reach its destination. The drive was undertaken as the result of the action of the Canadian Government, which, through the Department of the Interior, in 1929, authorized the purchase of three thousand head of Alaskan domesticated reindeer to be delivered at Kittigazuit. The purchase and drive of this herd of reindeer were made, not as repeatedly stated in the Press, to alleviate starvation amongst the Mackenzie Eskimo, but as the first step towards building up what it is hoped will become an important industry for the native population of Northern Canada. During the last two decades there has been a steady advance of settlement towards the north, and investigations carried out by private and Government initiative have definitely shown that natural resources of economic importance exist north of the 60th parallel of latitude, which is the boundary between the organized provinces and the North-West Territories.

The Minister of the Interior, advised by the North-West Territories' Council, administers the North-West Territories. While ready to encourage the development of the natural resources of the north, the administration is also solicitous for the protection and welfare of the aborigines of the country, and therefore for the conservation of fur-bearing and game animals upon which the inhabitants have to depend for their subsistence. While all Canadian Indians, as well as the Eskimo inhabiting the more accessible parts of the

north, have had contacts with white civilization for a century or more, some of the tribes dwelling along the shores of the Arctic Ocean, as recently as fifteen years ago, still lived under true Stone Age conditions, using bows and arrows and making fire by rubbing pieces of wood together. Through the advance of trading posts these Eskimo have now all been supplied with modern firearms as well as with other trade goods, and to obtain these commodities from the traders the Eskimo must hunt foxes, because the fur of this animal is the chief article his country produces which is of commercial value to the trader. At one time the fur of the white fox was of little or no value to the Eskimo, but in recent years his living in some districts has come to depend almost entirely upon the supply of these animals, and he has been directly affected by the fluctuation in fur prices in the world markets. While as yet there is no conclusive evidence that the number of white foxes in Arctic Canada is decreasing, the inroads that modern firearms and advancing civilization have been making on the larger species of game animals have become more and more evident. The musk-ox, which in historic times roamed over the entire northern fringe of the continent from Alaska to the west coast of Hudson Bay, as well as most of the Arctic islands, has long ago disappeared from Alaska, and on the mainland of Canada has been reduced to a few small herds. Killing of musk-oxen is prohibited, and the largest of these mainland herds for a number of years has been under Government protection in the Thelon Game Sanctuary. The Barren Ground caribou is still numerous in some parts of the Territories, but in recent years has entirely disappeared from large areas. The caribou of course is migratory in its habits, and during its semi-annual movements travels great distances. To what extent its disappearance from certain districts is due to natural causes, such as depletion of forage range or, as claimed by some, entirely to human agencies, can not at the present time be determined owing to the lack of sufficient data.

Before the rifle came into the hands of the Eskimo, he, like the game animals upon which he depended solely for his existence, led a roaming life. At certain times of the year seal or walrus were hunted with the harpoon or spear from the kayak or far out on the ice-bound sea. Towards summer he returned to the rivers on the mainland to catch fish, which were dried for the winter. In the autumn, when the caribou on its way to the winter pastures far to the south, near the edge of the great trans-continental forest, passed along the well-known routes of migration, the Eskimo was able to provide himself with meat and the indispensable skins for clothing and bedding. From the Pacific Ocean to Davis Strait the economy of the Eskimo is now definitely linked with the abundance or scarcity of white fox, which, like so many other of the animals of the north, are subject to certain fluctuations that are as yet imperfectly understood. And to the trader he must go not only for rifles and ammunition, but also in some districts for an ever-increasing part of his food supply. The change from an exclusive diet of fish, meat, and the fats of animals to the white man's food, which the Eskimo has not yet learned to use properly, has not been beneficial to him. The change has made him dependent on the trader, and in many ways has lowered his vitality and left him more susceptible to the attacks of diseases which here as elsewhere follow contact with civilization. The Eskimo in Canada were never

very numerous, because the rigorous nature of the country has never permitted a large population. The birth-rate amongst most Eskimo tribes has been high, but the death-rate during the first years of life has also been excessive. The census in 1931, which included all tribes of Canadian Eskimo, gave their number as 5979; in addition there are known to be 4046 Indians in the North-West Territories, besides about 1000 whites and half-breeds. This perhaps would appear to be an exceedingly small population for a territory of a million and a half square miles, or somewhat over one-third of all Canada, but it is very doubtful whether the fur and game supply alone would permit a much larger population.

While admittedly the Eskimo is now less dependent than formerly on the large game of the land and the sea, it is believed that nevertheless greater numbers of game animals are killed annually. It is true that no longer does the Eskimo follow the caribou migration, but whenever the occasion arises, because of the possession of modern firearms, larger numbers are killed. In the past, when the seal and the walrus were hunted from kayak or from the ice with harpoon or spear, and when the caribou were shot with bow and arrow from ambush, the hunt was a laborious process. The caribou hunt generally involved weeks or even months of preparation in building ingeniously devised stone fences and systems of cairns for the purpose of directing the advancing herds of caribou towards the shooting blinds behind which the hunter was concealed, or into rivers or lakes where the swimming animals would fall an easy prey to the hunter in his speedy kayak. To the Eskimo this method of hunting, although slow and laborious, was even more sure of results than the white man's way with the modern rifle. At the same time, for the preservation of game it was vastly superior because it was economical and silent. So much hard work was involved in the process of stalking and killing that seldom more animals were killed than could actually be utilized, and because a whole tribe or several families generally took part in the hunt and after each kill remained on the spot until all the meat was consumed or taken care of otherwise. The large increase in the number of white residents in the north of late has also materially increased the number of the larger game animals killed, although to offset this condition the issue of hunting-permits has been restricted to residents of the North-West Territories. The word "resident" in the Game Regulations means a British subject who has lived in the Territories for four years. The game conservation policy of the Dominion Government has done a great deal towards educating the natives of Canada to refrain from wanton killing of wild life in excess of their actual requirements and to observe hunting and trapping regulations. The Government has also established game reserves and wild life sanctuaries, and a further important link in this game conservation policy is the present experiment with domesticated reindeer. It is hoped that the reindeer will not only furnish an additional supply of meat and skins and thereby reduce the demand on the wild game, but will also open up new means of livelihood for at least a part of the Canadian Eskimo population.

With this in mind the Department of the Interior for a number of years studied the possibilities of establishing a reindeer industry in the north. The first step was taken with the appointing, in 1919, of the Royal Commission

on the Reindeer and Musk-ox, and since that body made its report [1] a large amount of information has been secured through investigation and experimental work. In the Arctic regions of Europe and Asia reindeer have been domesticated for at least 1500 years, but the first tame reindeer were brought to North America only in very recent times. The United States Government, on the initiative of Dr. Sheldon Jackson, in the years between 1891 and 1900, as a relief measure for the Alaskan Eskimo, imported from Siberia a total of 1280 head. So surprisingly well did the experiment succeed that from this small mother herd Alaska is reported to-day to have over half a million reindeer, while about a quarter of a million have been killed in supplying the native and white population with meat and hides. When, in 1926, it was decided by the Dominion Government that an experiment should be made in Canada with domesticated reindeer it was primarily the desire to promote the introduction of an industry which the natives could develop rather than establish a Government industry, and it was decided before incurring the expense involved in introducing reindeer on a large scale to have a thorough investigation made. It was considered that this investigation should cover the country between the Alaska–Yukon boundary on the west, the Coppermine river on the east, Great Bear Lake on the south, and the Arctic Ocean on the north. It was to have the character of a general reconnaissance, with special reference to reindeer pasture and to carrying capacity as well as physiographical features of importance to a future reindeer industry.

Since in Alaska the reindeer industry had become such an outstanding success, and since in northern Canada conditions in many ways resembled conditions found in Alaska, it was decided that the investigators previous to the field work in Canada should spend a season in Alaska, where an exhaustive study of the reindeer industry and its effects on the country and the people would be made. The author was entrusted with this investigation, and in May 1926, accompanied by his brother, Mr. Robert T. Porsild, proceeded to Alaska. Six months were spent in the central and western parts of that Territory. Most of the reindeer herds there were visited, and a large number of native and white owners of reindeer as well as Government officials connected with the reindeer industry, were interviewed. In order to complete this inquiry in a single season we travelled separately, and together a total of 7000 miles within Alaska. In addition to the information secured on the reindeer we obtained a representative collection of arctic and alpine plants of Alaska, aggregating six thousand herbarium sheets.

From our base at the head of Kotzebue Sound we proceeded by dog-team along the west and north coast of Alaska, in order to obtain a first-hand knowledge of the country through which a possible drive of reindeer from Alaska to Canada would have to pass. We left Kotzebue on January 1 and arrived at Aklavik on April 10. The journey from Kotzebue to Point Barrow, due to the lack of daylight and the continuous northern blizzards, was an extremely unpleasant one. The sledges used on this journey were of the Greenland type. They were 12 feet long and 30 inches wide, and weighed about 120 lb.

[1] Report of the Royal Commission on the Reindeer and Musk-ox to investigate the possibilities of the Reindeer and Musk-ox industries in the Arctic and Sub-Arctic regions of Canada, Ottawa, Department of the Interior, 1922.

each. The solid runners were shod with mild-tempered steel covered with a detachable 2½-inch wide hickory ski. In cold weather an ice shoe of frozen peat was put over the hickory ski. A canvas-covered frame about 4½ feet high was built over the sledges, and each sledge was provided with a light, wood-burning stove. These "covered" waggons were found quite comfortable whenever sufficient driftwood was obtainable, and did away with the often difficult and unpleasant task of erecting a snowhouse or tent in the dark after a long day's journey. East of Point Barrow, where in many places no driftwood was to be found and Primus stoves had to be used for cooking, the inside of the tent sledges soon became badly frosted and the canvas cover eventually had to be discarded. On arrival at Aklavik our sledge odometer registered a travelled distance of 1600 statute miles or an average of 26·4 miles per travelling day.

Mackenzie District.—During the summer of 1927 a grazing survey was made of the Mackenzie Delta, and of the Arctic coast and hinterland between the Mackenzie and Anderson rivers. The same territory was again covered by dog-team the following winter in order to ascertain snow conditions. On 19 February 1928 we left our base in the Mackenzie Delta, again travelling by dog-team, following the Mackenzie river as far as Norman. At this point we turned east, crossing Great Bear Lake. A base was established at the head of Dease Arm, near the site of old Fort Confidence built by Dease and Simpson on their exploration expedition, 1837–39. Of the old Fort but two stone chimneys remained. During the spring a number of sledge journeys were undertaken from this base to the north shore of Great Bear Lake, and to the barrens to the north and east. On May 2 we reached the Coppermine river. The rapid advance of spring made further cross-country travelling by sledge impossible. On returning to our base on the 8th we found that the snow had entirely disappeared, the rivers were running, and the first spring flowers were in bloom. However, since the ice in the main body of the lake still remained unbroken for more than a month, travelling was still possible on the ice. A month was spent making a compass traverse of the shore-line of Dease Bay. One week was occupied making observations on a peculiar rhythmic oscillation of the waters of Dease Bay. A tide gauge was constructed and hourly readings were taken continuously for five days. A regular rise and fall was recorded, having a maximum amplitude of 7 inches, and was found to occur seven or eight times during twenty-four hours. These seiches produced a reversing current in the bay, resembling regular tide rips, sufficiently strong to prevent the formation of ice in a number of narrows between islands and the main shore.[1]

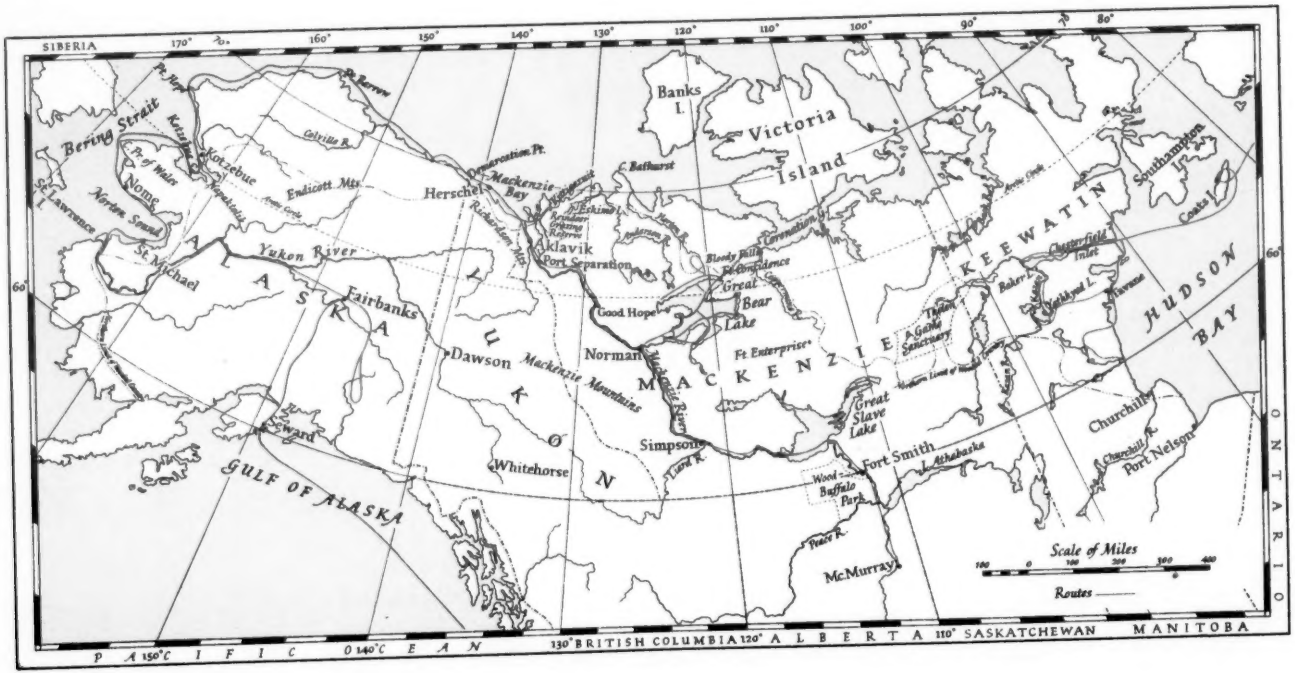
During the latter part of June a trip was made on foot with pack-dogs from the north shore of Dease Bay due north for a distance of approximately 40 miles. On this trip a range of gravel hills was discovered running in a north-east to south-west direction and estimated to be more than 100 miles long. Subsequently it was found that farther west the hills approached to within a few miles of the north shore of Smith Arm. The hills rise from 100 to 400 feet above the contiguous plain, and are thickly strewn with glacial erratics mostly

[1] A. E. Porsild, "Notes on Seiches and Currents in Great Bear Lake," *Geographical Review*, vol. 22, 1932, p. 474.

of sandstone, but limestone, quartz, granite and diabase boulders were also noticed. Near the northern edge of these hills sandstone *in situ* was observed in the bottom of a ravine. These hills appeared to be a system of glacial moraines, and are believed in places to be underlain by the remains of a glacier. Numerous kettle lakes and pit-holes, mostly without an outlet, occur in many places and, judging from the unconsolidated slopes, caving and slumping appear to be in constant progress. During the remainder of the open season the entire shore-line of the lake was examined. We returned to Ottawa on 26 October 1928. During the thirty months spent in the field a distance of approximately 15,000 miles had been travelled by dog-team, canoe, motor boat, and last but not least, on foot.[1] Botanical and zoological collections were made whenever time and transportation permitted. The botanical collections from the 1926–28 expedition aggregated 15,000 herbarium sheets of vascular plants and 5000 specimens of cryptogams. Collections which almost equal the above have subsequently been added. These came from both the Mackenzie and Keewatin Districts.

Keewatin District.—An area adjacent to the Mackenzie Delta for practical reasons has been selected as the home of the first experimental reindeer herd. When the experience gained at the Mackenzie station indicates that the reindeer industry is likely to become as successful in Canada as it has been in Alaska, new experimental reindeer stations can be established across the northern part of the North-West Territories. The 1927–28 grazing survey had been extended as far east as the Coppermine only, and in 1930 the writer was therefore instructed to make a grazing survey of the central Keewatin District west of Hudson Bay between Churchill and Chesterfield Inlet. If possible the survey was to include the hinterland as far west as the Kazan river. Since it was desirable that the work should be completed in one season two aeroplanes of the Royal Canadian Air Force were made available during the early part of the survey. By using aeroplanes it was possible first by reconnaissance flights to select the areas that appeared to be the most suitable for reindeer pasture and secondly, to transport personnel and equipment to the place selected from the air as being the most advantageous for the start of the ground work. Since the canoe to be used by the party had to be carried on the aeroplane, a type specially designed for this purpose was selected for the expedition. This canoe fits snugly against the underside of the fuselage of the aircraft. It is 18 feet long and fairly narrow, very low, and nearly flat-bottomed. It has a square stern and is built for a light outboard engine. With a minimum of freeboard it will carry a load of 800 lb., and with a light-weight $1\frac{1}{2}$-h.p. outboard engine will make from 5 to 6 miles per hour, according to load and weather. Due to the square stern and the absence of a keel the canoe does not paddle well. A great improvement was made on this canoe by the fastening of strips of waterproofed canvas 2 feet wide to the gunwale of the canoe. The inside edge of this canvas was provided with brass eyelets, so that when loaded the canvas could be lashed over the load leaving an opening for each of the crew. With this arrangement the canoe was made much more

[1] For a complete account of the 1926–28 expedition see A. E. Porsild, 'Reindeer Grazing in North-West Canada,' Ottawa, 1929, published by the Department of the Interior.


SIBERIA
170°
160°
150°
140°
130°
120°
110°
100°
90°
80°
Pt. Hope
Pt. Barrow
Bering Strait
Kotzebue
Kotzebue Sd.
Pt. of Wales
Nome
Lawrence
Norton Sound
Selwyn R.
Endicott Mts.
Herschel
Mackenzie Bay
Richardson Mts.
Aklavik
Port Separation
St. Michael
Yukon River
ALASKA
Fairbanks
YUKON
Dawson
Mackenzie Mountains
Norman
Good Hope
Great Bear Lake
Ft. Enterprise
MACKENZIE
Great Slave Lake
Simpson
Fort Smith
Athabaska L.
Wood Buffalo Park
Peace R.
McMurray
Whitehorse
Seward
GULF OF ALASKA
Banks I.
Victoria Island
Bathurst
Coronation Pt.
Coronation G.
Bloody Falls
Ft. Providence
Southampton I.
Coats I.
KEEWATIN
Chesterfield Inlet
Baker L.
Yathkyed L.
Tavani
Thelon Game Sanctuary
HUDSON BAY
Churchill
Churchill R.
Port Nelson
ONTARIO
60°
Scale of Miles
100 0 100 200 300 400
Routes
PACIFIC OCEAN
150°
140°
130°
BRITISH COLUMBIA
120°
ALBERTA
110°
SASKATCHEWAN
MANITOBA

seaworthy, and with as little as 2 to 3 inches of freeboard was comparatively safe even in fairly rough water. For his companion the writer selected Mr. H. W. Bryenton of The Pas, Manitoba, known to him as a cheerful companion and a resourceful traveller of great experience in northern work. Nearly two weeks were spent in the vicinity of Churchill, pending the opening up of the lakes of the interior. Reconnaissance flights were made from Churchill up the Tha-anne river, thence due east to Eskimo Point and Mistake Bay, and from the latter place to Rankin Inlet and again due west to Yathkyed Lake on the Kazan. During the reconnaissance several landings were made, and, when flying conditions permitted flights were made at a fairly low altitude. As I had experienced on earlier flights in Alaska in 1929 it was possible from altitudes of 1000 to 3000 feet to recognize with surprising accuracy the more important plant formations as well as forage cover. The flights showed that, generally speaking, the area comprising the northern part of the west coast of Hudson Bay from Chesterfield south to Dawson Inlet, and inland as far west as the outlet of Baker Lake, is entirely unsuited to reindeer. This area is a low peneplain having a maximum altitude of perhaps less than 1000 feet. The rocks are pre-Cambrian and everywhere show abundance of glacial striation. Moraines and other forms of glacial deposits are rarely seen here. Viewed from an aeroplane, the almost total absence of soil and closed plant cover is most striking. Black rock lichens here and there lend a sombre tinge to the land, but in most places the grey or light-red colour of the gneiss and granite is dominant. North of this area the narrow fjord of Chesterfield Inlet, which is continued by Baker Lake, penetrates 200 miles into the heart of the "Barren Grounds." The inlet is navigable by sea-going vessels to the very head of Baker Lake.

South of Dawson Inlet the character of the country changes. The pre-Cambrian rocks are well covered by a thick mantle of glacial till, and but here and there are rock exposures seen. The country rises from the low and shallow west coast of Hudson Bay in a series of almost level prairie-like, lake-filled plains to the height of land towards the Kazan river. Viewed from the air the most striking feature of this 100–150-mile wide coastal plain is the great abundance of lakes and the total absence of well-defined drainage systems. The waters from one lake merely spill over a rocky ledge into the next lake, and even from the air it is with the greatest difficulty that the rivers can be followed. With its countless lakes, which cover more than half the surface, the country strangely resembles a tidal flat which has just been exposed by the receding tide. No doubt owing to the variation in their flora of algae and diatoms, the waters of no two of these lakes are of the same colour. Some are almost black, but most are yellowish-brown, and some even milky white. In none of them are the waters clear and transparent to a depth of over a few feet.

Yathkyed Lake.—On July 30 the party landed at the outlet of Yathkyed Lake and the aeroplanes were returned to their base at Cormorant Lake, Manitoba. The month of August was spent making a complete survey of the shore-line and country bordering Yathkyed Lake, and of the Lower Kazan to Baker Lake. A compass traverse was made along our route of travel from which a rough sketch-map of Yathkyed Lake and the Lower Kazan has been

made. J. B. Tyrrell in 1894 traversed the north-west end of the lake, and in his "Report on the Doobaunt, Kazan, and Ferguson Rivers," *Geol. Sur. of Canada, Ann. Rep.*, vol. ix, 1896, accurately describes the shore-line between the inlet and outlet of Kazan river. Members of the 5th Thule Expedition, 1921–24, visited the lower Kazan river and Yathkyed Lake, and a fairly comprehensive description of the country is given by Birket-Smith, "Geogr. Notes on the Barren Grounds," Fifth Thule Expedition, vol. 1, No. 4. In addition to the above expedition a few white travellers, mostly officials of the Department of the Interior, of the Royal Canadian Mounted Police, and of trading companies, have visited the Kazan Basin during the winter. Our knowledge of that country however still remains fragmentary and it is therefore thought that the following notes, however incomplete, may be of some interest.

Yathkyed Lake, also known by its Eskimo name Hikoligjuaq (which means "large, ice-filled"), is approximately 53 miles long with a maximum width of 22 miles near its north-west end. By two independent aneroid readings its elevation above sea-level was determined as being approximately 500 feet. Although no soundings were made in the centre of the lake, it appears to be shallow everywhere, the greatest depth obtained being 50 feet. A large island of granite cut by numerous dykes of diabase almost separates the south-eastern arm from the main body of the lake. Large numbers of small islands, some rocky and some mere heaps of boulders, are seen everywhere in the lake. Some of the boulder islands are annular in outline, with a truncate, crater-like top. These, as well as numerous reefs and boulder walls, which in many places form the shore-line of this and other lakes on the Kazan, are formed of angular boulders in which small pebbles and sand are entirely absent, and no doubt have been pushed up from the shallow lake bottom by lateral pressure of the ice. Two entirely distinct agencies are believed to cause this pressure:

(1) Pressure exerted during break-up against the windward shore by large fields of unbroken ice set in motion by the wind.

(2) Lateral pressure during the winter by expansion of the solid sheet of ice covering the lake caused by changing temperature.

The mechanics of this pressure are not clearly understood, but it is well known by all travellers that pressure ridges occur in all large northern lakes in certain places against the shore, or between two opposite points in the lake where early in the winter a fissure will be formed. This fissure or lead expands and contracts with changing temperature. Upon contracting the ice formed in the lead will be crushed, and at the end of the winter a pressure ridge, often 5 to 10 feet high, is formed. Pressure ridges are formed in the same place each winter. The boulder walls' shores in Yathkyed Lake are generally from 10 to 30 feet high. The side facing the lake is always entirely devoid of lichens or moss, while the inside of the wall is well covered by these plants. Disturbances in the walls are frequent and may easily be noted by the orientation of the lichen-covered face of the boulders on the inside wall.

The Kazan river enters Yathkyed Lake near its western end. The outlet is on the north shore through a broad channel, which almost immediately opens into a lake bordered by low, grassy meadows. Leaving the lake, the river soon becomes narrow and swift with numerous rapids, some of which

cannot be navigated. In approximate latitude 63° 29′ N. the river enters a lake about 12 miles long and 3 to 5 miles wide of very regular outline. From the north end of this lake it passes through a range of low but very rugged granite hills. North of this range the river makes a sharp bend towards the east, and almost immediately empties into a long and narrow lake about 30 miles long, but not more than from a quarter of a mile to 2 miles wide. The only tributary of fair size enters the Kazan from the west at the head of this lake. On both shores this lake is enclosed by low, rocky hills having a mean elevation above the lake of from 100 to 200 feet. A short distance north of the outlet of this lake the river drops about 30 feet through a long, cascade-like rapid. Below this rapid it continues for 12 miles, and then through a series of rapids the channel contracts abruptly, and through three channels, formed by one large and one small rocky island, the river drops over the Kazan Falls into a narrow canyon between perpendicular walls from 50 to 75 feet in height. Down a winding stairway formed by the erosion of a soft vein of pegmatite a native, whom we met above the falls, took us to the surging maelstrom at the foot. In a deep and clear pool he showed us where the natives spear salmon trout. On the bottom of the pool we saw several of these large and beautiful fish, that ascend the Kazan from the sea as far as the falls, but according to our native informant are never taken above the falls. Below the falls the river continues its turbulent course for about a mile through the canyon before it emerges into a broad and shallow valley, through which it winds its way between gravelly banks towards Baker Lake. The total drop from the head of the rapid above the falls to the foot of the canyon is estimated to be at least 100 feet.

A short distance below the fall the archean rocks are overlain by a soft, bright vermilion sandstone. From a hill 600 feet high a short distance east of the river, Sugar Loaf Mountain on the south shore of Baker Lake was visible. The slopes of the first-mentioned hill as well as the very crest showed series of raised shore-lines formed of boulders similar to the boulder reefs observed on Yathkyed Lake. The last 20 or 30 miles before entering Baker Lake the banks of the Kazan are formed of blue boulder clay rich in marine shells. Between Yathkyed and Baker Lakes the Kazan, between lakes, is everywhere swift, with a current ranging from 4 to 8 miles per hour. In addition to the Kazan Falls, around which there is an easy portage about three-quarters of a mile long, we descended in all fifteen rapids, of which all but two could be navigated by lowering the canoe at the end of a line. From the very conspicuous and isolated Sugar Loaf Mountain on the south shore of Baker Lake one commands an excellent view of the eastern portion of Baker Lake and the country far to the south. On a clear day the buildings at Baker Lake post and the mouth and lower courses of the Doobaunt River are clearly visible. J. W. Tyrrell [1] in his map of Baker Lake, gives the altitude of Sugar Loaf Mountain at 1200 feet, while Birket-Smith [2] says it is about 360 metres. Two independent aneroid readings however gave its elevation above Baker Lake at 600 feet only. The hill rises in terraces from a low, undulating plain and is

[1] J. W. Tyrrell, "Report on an exploratory survey between Great Slave Lake and Hudson Bay," *Ann. Rep. Dept. Interior*, 1901, Topogr. Surv. of Canada.

[2] Birket-Smith, p. 112.

of a hard, metamorphosed sandstone. Several raised shore-lines occur on the sides of the hill. At Chesterfield we were picked up on September 14 by the S.S. *Beothic*, which touched at this post on her return voyage from her annual inspection trip to the Eastern Arctic for the Department of the Interior.

Temperatures somewhat higher than expected [1] were experienced during July and August. Since so little is known of the summer temperatures of the central Barren Grounds, the observations, although incomplete and taken in the course of the trip, are recorded below. Air temperatures were recorded by swing thermometer. Water temperatures were taken from a canoe some distance from the shore and well below the surface.

	Air Temperatures		*Water Temperatures*		*Remarks*
July	31	61° F. Noon			Clear.
Aug.	2	61 ,,			Clear.
	4	60 ,,	61° F.	Yathkyed Lake	North wind.
	5	60 ,,	61	,, ,,	South wind, rain.
	6	56 ,,	56	,, ,,	Strong westerly wind.
	7	46 ,,			Strong north-westerly wind, rain.
	8	52 ,,			Moderate wind, rain.
	9	54 ,,	53	,, ,,	Clear and calm.
	10	59 ,,	56	,, ,,	Clear and calm.
	11	62 ,,			Southerly wind, showers.
	12	58 ,,			Stormy, overcast.
		48 9.00 p.m.			Clear and calm.
	13	54 Noon			Clear, light breeze.
	15	62 ,,	58	Kazan river	Clear, strong south wind.
	16	80 ,,			Hazy, light southerly wind.
	17	72 ,,			Hazy, light southerly wind.
	18	62 ,,			Overcast, southerly wind.
	21	70 ,,			Overcast, southerly wind.
	22	62 ,,	60	,, ,,	Calm, rain.
	23	56 ,,			Northerly storm, rain.
	26		54	Baker Lake [2]	

General Observations on the Flora.—In a brief synopsis of the botanical results of the expedition two features especially are worthy of note:

(1) Due to the absence of high mountains and to the general uniformity of the geological formation there is a striking uniformity in the composition of the flora.

(2) Even more striking than the uniformity of the flora is its obvious youth. On the coast and hinterland from sea to the 300–500-foot level, which is generally found a considerable distance inland, stabilized plant formations are indeed rarely seen.

With the exception of the south-western corner the Keewatin District is entirely treeless. On the Kazan, according to Tyrrell,[3] the last outpost of the

[1] Birket-Smith, p. 72.

[2] J. B. Tyrrell, p. 135, on 31 August 1894, recorded the temperature of the waters of Yathkyed at 46° F., and in 1893, on September 6, found the waters of Baker Lake registering 41° F.

[3] J. B. Tyrrell, p. 133.

forest is found a short distance above Yathkyed Lake in approximate latitude 62° 24′ N. Similar isolated clumps of mixed black spruce (*Picea mariana*) and larch (*Larix laricina*) were observed by us on the upper Tha-anne River and near Padlei on the Maguse River. The group of trees reported by Birket-Smith [1] near the outlet of Yathkyed Lake is probably referable to willows rather than to spruce or larch. In the Mackenzie District the white spruce (*Picea glauca*) occupies the most northerly outposts of the forest, while the larch and black spruce take its place at the tree limit in Keewatin District. In the Kazan basin the climate appears to be much drier and a good deal warmer than that of the shores of Hudson Bay. When we left the Bay on July 31 the seasonal development of the vegetation there was at its climax, while at Yathkyed Lake on the same date practically all species had gone to seed. Extensive prairie or meadow-like plains, broken here and there by isolated granite "islands" were noticed in a number of places in the Yathkyed basin. The soil on these plains was a light, sandy loam, covered by a layer of humus seldom exceeding 6 to 8 inches in thickness. Most of these plains appear to be covered by water during the early summer. The permanent frost was found at a depth of from 1 to 2 feet. Willow thickets, rarely exceeding 8 to 10 feet in height, were seen in well-protected places only, where abundant snow cover was ensured during the winter, whereas the alder (*Alnus crispa*), which in Western Canada and in Alaska occurs far north of the limit of trees, was not observed north of the Tha-anne river. On the hillsides and valley slopes heath composed chiefly of *Dryas integrifolia*, *Empetrum nigrum*, *Myrtillus uliginosa* var. *alpina*, *Betula glandulosa* and dwarf willows were common. The luxurious heath so characteristic of similar habitats in the west, in which the chief components are *Betula glandulosa*, *Eriophorum vaginatum*, *Ledum decumbens*, *Vaccinium Vitis-Idaea*, with a luxuriant undergrowth of fruticose lichens, was entirely absent. Nor were the very common "niggerhead" tussocks of that formation observed. Hilltops and ridges everywhere were inhabited only by xerophytic *fjaeldmark* plants capable of withstanding extreme drought during the summer and absence of snow cover during the winter. The principal species of vascular plants found here were *Festuca ovina*, *Poa glauca*, *Carex nardina*, *C. capillaris*, *Saxifraga tricuspidata*, *Dryas integrifolia*, *Arctostaphylos alpina* and *Myrtillus uliginosa* var. *alpina*. In addition a number of lichens and mosses were noted.

From the point of view of reindeer pasture a comparison of the composition of the flora of the Barren Grounds of the Keewatin and Mackenzie Districts at once revealed a striking dissimilarity. In the west the above-mentioned luxuriant heath, rich in fruticose lichens, which afford excellent winter pasture for reindeer and caribou, is generally found a short distance from the sea-coast. In Keewatin the transition from the sea-coast flora to that of the interior is much less marked. The lichen heath does not extend far beyond the northern limit of trees. For the grazing of domesticated reindeer therefore the greater part of the Keewatin District must be classified as summer pasture only.

The Reindeer Drive.—Following the publication of my report of the grazing investigation in the Mackenzie District the Dominion Government in 1929

[1] Birket-Smith, p. 114.

made provision for the expenditure necessary for the purchase of a herd of three thousand head of Alaskan reindeer and for the establishment of a permanent experimental reindeer station to be built on the east branch of the Mackenzie river at the delta. The selection, under the supervision of the writer, of the reindeer to be purchased took place in the mountains near the source of the Napaktolik river in the Kotzebue Sound region, on the winter range of the largest reindeer company in Alaska. Considerable difficulties were encountered in rounding up the large number of reindeer required from which to make the selection. Two months were thus spent bringing together a number of small herds which were scattered over a range of more than 1000 square miles. In a forested valley a huge timber corral was constructed capable of holding ten thousand head of reindeer. In the selection which took place early in December each animal was carefully examined before passing inspection, and 2890 females from one to three years old, 317 bulls, and 308 steers were selected.

A few days before Christmas the herd was on its way on the long journey from Napaktolik to the Mackenzie Delta. Almost at once the vendors, who had undertaken to deliver the deer at the Mackenzie Delta, experienced great difficulties in overcoming the natural homing instinct of the reindeer. Numerous cows had become separated from their last year's offspring and wanted to return. Under normal conditions in a reindeer herd the percentage of steers is much higher than in the selected herd at that time. Due to the presence of the more docile and less spirited steers such a herd is much more easily handled by the herders. Every precaution therefore had to be taken to prevent small bands from breaking away from the main herd, but again and again in the initial stages of the drive during a blizzard the entire herd or part of it would break away and return to the range whence it had started weeks or even months before. The first stage of the drive ended in March 1930, when the herd had reached Hunt river, a tributary of the Kobuk. The fawning season was then near at hand, and this prevented further movement until the next freeze-up, when travelling would again become possible.

Against the advice of the author, the vendors had decided not to follow the somewhat longer route around the west and north coast of Alaska, where the presence of a number of native-owned reindeer herds presented the danger of getting the herds mixed, but to take a shorter route through a pass in the Brooks Mountains. New and perplexing problems were encountered the following winter due to the depth of snow in the mountain valleys and the consequent difficulty in transporting the supplies and equipment of the expedition. The vendors originally had planned to use reindeer steers only for hauling the supplies. So much time however was lost in breaking steers to harness and in the daily routine of harnessing the fifty sledge deer required to haul the equipment that this plan was soon abandoned. An attempt was made to use aeroplanes for placing advance caches of supplies along the route of travel, but the hazard of flying across the but partly mapped Brooks Range during the dark period of the year, coupled with the excessive cost, put great obstacles in the way of carrying out this plan. Eventually the time-honoured dog-team transport solved the problem. For a time fifteen dog-teams were

employed for relaying supplies across the divide to the Etivluk river, a tributary to the Colville river.

As a result of the first fawning over 1500 fawns had been added to the herd, and it became necessary rather than kill off this unneeded surplus to cut out about five hundred females with their fawns and drive them back to Napaktolik. The second fawning took place in the spring of 1931, on the Colville flats on the north coast of Alaska. Three Lapp herders had been selected by the writer in Lapland in the summer of 1931, and with their families these men were brought to Canada to take care of the reindeer upon delivery and to teach the young Canadian Eskimo the art of herding reindeer. And when in January 1932 no news had been received from the drive for more than six months the writer, accompanied by one of the Lapland herders, started from Kittigazuit by dog-team along the north coast of Alaska in order to meet the herd. Owing to the scarcity that winter of dogs and dog-feed in northern Alaska we found it impossible to secure dog-feed along the route or to engage dog-teams to assist us in hauling our supplies. Leaving Herschel Island we were therefore compelled to carry supplies and dog-feed for forty days. Following a three weeks' journey we found the reindeer herd a short distance east of the Colville Delta.

The previous summer Andrew Bahr, the Lapp in charge of the drive, had experienced great difficulties with his men. Of the crew of ten Lapp and Eskimo herders that had started with the herd from Napaktolik none was left. Because of inexperienced and insufficient help during the previous autumn about one-third of the herd had wandered off. After a search of two months the missing animals had been located in the mountains far to the south, but it had not been found possible to drive them back to the Colville Delta with the number of men available. Bahr therefore had decided to give up further attempts and to depend on next year's increase to build up the remaining herd, then estimated at somewhat over two thousand head. Bahr had managed to secure a new crew of Eskimo herders from Kobuk and from the Point Barrow region, but as some of these boys were quite young and inexperienced he did not expect to make much further progress that winter (1931–32). Nothing therefore could be accomplished by remaining with the drive, so we set out on our return journey with no delay, returning to Kittigazuit after sixty days of travelling. To one unfamiliar with travelling conditions in north Alaska it would perhaps appear that no very great effort was being made by those in charge of the drive to reach their destination as speedily as possible. It is quite easy to see now that a great many delays might have been avoided if a different route had been followed, and if in the first place a different plan had been adopted for transporting the travelling gear of the caravan and in keeping it in supplies and necessaries. Andrew Bahr however was an old man when the drive started; how old he does not know himself, and conditions on the north coast of Alaska were entirely unknown to him. It should be remembered also that a great many difficulties are encountered on a trek such as this, through an uninhabited and inhospitable country; that the climate of northern Alaska is perhaps the most severe on the North American continent; that in the winter months during the entire drive bands of wolves continually harassed the herd, at times taking a great

toll and compelling the herders to remain on watch day and night. Above all, it should be remembered that it is during but a few months each year that it is possible to move a large herd of reindeer for any great distance. Whereas in northern Europe the fawns are born in May and June, in Alaska the first fawns appear early in April, and from the middle of March the cows are unable to stand the hardships of daily moving. The fawning is over by the end of May. In July the fawns are strong enough to travel and to cross fair-sized rivers, but at this time of the year the mosquitoes and flies are at their worst and the animals have to be driven out to the sea-coast or to some high mountain in order to escape their tormentors. For a short period during August the herd may be moved if some means are available for moving the camp equipment. Towards the end of August the rutting commences and continues during the month of September. October is the month of freeze-up, but the ice is not sufficiently strong on the rivers and lakes to permit the crossing of the herd.

There remains, then, but little more than four months during which it is possible to move the herd. But on the north coast of Alaska, north of the 70th parallel of latitude, the sun is below the horizon for over two months, and because of the shortness of the days all travelling has to be done around the period of full moon. Furthermore, because of the proximity of open water, at this time, since the Arctic Ocean is only partly frozen, December and January are the stormiest and most unpleasant months of the year. Fuel exists along the coast only in the shape of driftwood, and more often than not is completely covered by huge snowdrifts. At some distance from the coast, where the best winter pasture is found, the traveller must content himself with the insufficient heat supplied by an oil stove, which source of heat moreover is quite unsuitable for the drying of wet fur clothes.

In the winter of 1932–33 the reindeer finally crossed the Alaska–Canada boundary. In order to expedite the movement our three Lapp herders had, at the request of the vendors, joined the drive. We also undertook to look after the transport of equipment and supplies, and with this in view my brother joined the drive from January until the end of April. Every one therefore hoped that the drive would cross the Mackenzie Delta that winter, but when the west side was reached in March, Bahr felt that owing to the proximity of the fawning season the risk was too great, and the drive thus stopped short of its destination by a mere 100 miles. The winter of 1933–34 was the coldest and most stormy ever recorded in the Mackenzie Delta. For two months the temperature never rose above 35° below zero. In January, as it turned out, an ill-timed attempt was made to make a non-stop dash across Mackenzie Bay from Shingle Point to the north end of Richards Island. In a straight line the distance is but 50 miles, and it was thought that the deer, then in good shape, would stand the trip without food and without rest. Half-way across a gale sprang up. The temperature was 48° below zero, and when the herders had travelled for a day and a half without rest and without food they were compelled to give up the drive and save their own lives. In the blizzard the herd split up into numerous small bands. After the storm two hundred reindeer were thought to have perished on the ice due to the cold and to exhaustion, and the rest were scattered over a distance of

50 miles along the west side of the delta. Bahr with his Eskimo guide lost their way and very nearly froze to death, whilst three of the herders had their hands and feet severely frozen. When three weeks later the herd had again been rounded up the animals had become so poor in condition that further attempts at crossing the Mackenzie that winter had to be abandoned.

The winter of 1934–35 was exceptionally mild, and the Mackenzie river delta froze a month later than usual. The weather remained pleasant and settled throughout November and December, and everything looked as though the herd might finally reach "The Promised Land." Every precaution that might ensure success had been taken. Caches of food for the herders, as well as great piles of reindeer "moss" for the train of sledge deer that were hauling the camp gear, had been established at short intervals along the proposed route across the edge of the Mackenzie Delta. Everything was ready for an early start the first week of December, when a foehn or *chinook* changed everything. For a fortnight the temperature remained above freezing. All the snow disappeared from land and ice. Although the sun had disappeared below the horizon the willows along the river banks dropped their bud scales. On the sea a narrow rim of ice remained along the shore to the edge of the shallow water, but here as well as on the rivers it was smooth and slippery and entirely impassable for hoofed animals. Farther out the sea was clear of ice as far as one could see from an aeroplane flying at an altitude of 5000 feet. New snow eventually fell, but it would not stick to the smooth ice. Nothing could be done but wait. Any one who has to deal with reindeer must, like the Lapp, possess an infinite stock of patience. Whether this is natural to the Lapp or whether the trait has been developed through countless generations of reindeer herders I am not prepared to say. The fact however remains that the Lapp possesses an amazing capacity for waiting, and in this quality even surpasses the stoical Eskimo. Finally in February an abundance of snow fell, and on February 18 the drive across the delta commenced. In record marches the herd crossed without incident in three days; but it had taken two years before conditions were ideal for such an undertaking. One week later gales again swept the ice, leaving it snowless for the remainder of the winter.

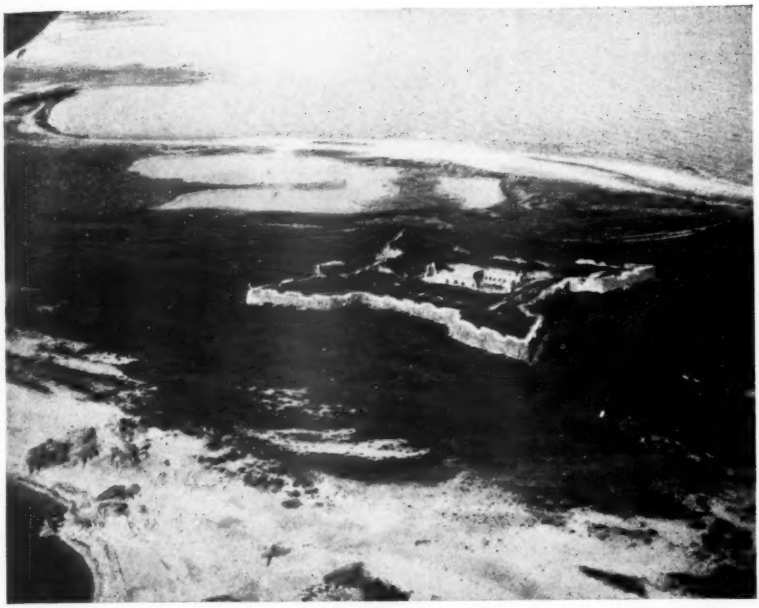
About two weeks were occupied in resting the herd and in moving it slowly to the corrals at the Government Reindeer Station, where on March 6 the deer were put through the corrals and counted and delivery accepted on behalf of the Dominion Department of the Interior. The great day had arrived, the day which marked the end of this long and trying journey which had been so fraught with disappointment, had caused so much waste of time and effort, and which had so often taxed our patience almost to the point of breaking—an Arctic Odyssey which had ended happily. The main camp of the new reindeer station had been established on the timbered slopes on the east bank of the easternmost channel of the Mackenzie river delta, where during the last few years a small hamlet had grown up to provide living accommodation and warehouse facilities for the staff connected with the experiment. On the Arctic coast, near the now deserted Eskimo village of Kittigazuit in the heart of the summer range, our summer camp and corrals had been located. Two long wire fences lead to a large, circular palisaded enclosure from which a complicated system of holding pens, separated by sliding gates, lead to the

30-foot-long chute, so designed that only one reindeer at a time is able to pass, thus permitting a careful and thorough inspection. A total of 2370 reindeer was received, and of this number 1500 were females. Of the original stock of 3400 selected five years before at Napaktolik but one-fifth remained. Of the rest some had been returned to the home range or had strayed away, while others had fallen a prey to the wolves, blizzards, or starvation, or had met with other accidents. The other four-fifths of the herd received at Kittigazuit were young animals born during the trek. But what indeed could be a better guarantee that the animals received were strong and healthy? Truly a "survival of the fittest."

Conclusion.—Grazing surveys conducted by the writer during the eight summers and five winters he has spent in the Mackenzie and Keewatin Districts have shown that large areas from the northern edge of the trans-continental forest north towards the Arctic Ocean are suitable for the grazing of reindeer. A very considerable portion of this country however is unsuitable because of its rocky nature, and when at some future date Canada's North-West Territories have been fully mapped, it will probably be found that 50 per cent. of the surface is covered with lakes. Reindeer ranching under a system such as has been evolved in Alaska [1] having a fixed grazing allotment grazed in seasonal rotation, with establishments of a permanent nature, requires summer and winter pastures. In the entire North-West Territories, with the exception of the northern archipelago and the sea-coast, flies and mosquitoes occur in such unbelievable numbers during the short summer season that neither the reindeer nor the hardiest of herders can endure their torments. The only method of escaping these pests is by moving the herd during June and July to the sea-coast, where the cooling effect of the sea gives some measure of relief, or to drive the deer to high hills. Nowhere in the area under consideration are there hills high enough to permit the reindeer to escape the flies during the summer, and for this reason reindeer ranching in Arctic Canada will always be definitely limited to the sea-coast and adjacent hinterland. The interior can never be utilized as reindeer pasture except by nomadic reindeer tribes. With but one exception all Canadian Eskimo tribes live on the coast and are not content to be away from the sea. The Indians, as far as the few indications given by the experience of Alaskan commercial reindeer companies go, do not appear to adapt themselves to the life of a reindeer herder.

An area east of the Mackenzie Delta has been set aside as a grazing reservation for the first experimental reindeer herd. This reserve, known as the Kittigazuit Reindeer Grazing Preserve, covers roughly 6000 square miles, and was surveyed in the summer of 1935 by oblique aerial photographs. Detailed grazing surveys of this reserve indicate that it will support indefinitely a total of 25,000 reindeer. Adjacent areas approximating 10,000 square miles in extent are available in the north-western Mackenzie District. The pasturable country north and north-east of Great Bear Lake comprises an additional 38,000 square miles. The largest territory however suitable for reindeer ranching is along the west coast of Hudson Bay from Nelson river north to

[1] See *e.g.* L. J. Palmer, "Improved Reindeer Handling," U.S. Dept. Agric. Circ. No. 82, 1929.



Ruins of Fort Prince of Wales at the mouth of Churchill River, built by the Hudson's Bay Company in 1742

Looking N.W. across the eastern estuary of Mackenzie River. The arctic ice-pack is seen off the N. end of Richards Island

Arctic prairie east of Yathkyed Lake

Part of the herd in Kittigazuit Reindeer Grazing Preserve during the 1935 fawning season

The eastern and smallest portion of the Kazan Falls, Lat. 63° 46′ N.

Dawson Inlet. Evidences of overgrazing by caribou herds were found in many places in the interior of Keewatin District. The reindeer herd, following delivery in March 1935, was placed on the new Grazing Preserve, where it has since been maintained under close supervision. Until the herd has become well established and the homing instinct developed, herders are watching the movements of the deer day and night. At the first fawning season, in the spring of 1935, about one thousand fawns were born. It is anticipated that in a few years the herd will have increased to about five thousand, which number is sufficient to provide a surplus of a thousand steers annually. Under the tuition of experienced reindeer herders in the Government service young Eskimo apprentices are being taught to take care of the reindeer, and when they gain skill and experience the next stage will be entered upon in the development of the reindeer industry.

DISCUSSION

Before the paper the PRESIDENT (Major-General Sir PERCY COX) said: The subject of the paper to-night is "A Four-Year Trail from Alaska to the Mackenzie Delta," and the lecturer is going to tell us of a wonderful and most courageous enterprise on the part of the Dominion Government to try to establish a colony of reindeer in the Mackenzie province. To do that they bought three thousand reindeer in Alaska. Those reindeer were driven, over four seasons, a distance of 1500 miles at least, even if they could have taken the straightest route; but they had of course to make detours, and because of those detours it is impossible to say precisely what the distance covered was. It was at any rate an astonishing episode.

You must not expect anything spectacular, but the subject is one of much interest. Mr. Erling Porsild, the lecturer, is a Dane by birth, but he has been in the employment of the Canadian Government for twelve or thirteen years and is a naturalized British subject. By profession he is a botanist. His father, also a distinguished botanist, has spent the last thirty years in Greenland and is still in administrative charge of the Station on Disko Island. Mr. Erling Porsild being in the service of the Canadian Government when they decided to undertake this great experiment, he was naturally the person to be chosen, in view of his wanderings in pursuance of his study of botany in that region, for the management of the enterprise, and he continued in charge throughout the trek; not always remaining with them, but periodically visiting the head of the trek, as it were, and seeing that things were going on as they should. The tale he has to tell is one of extraordinary interest, and I will now ask Mr. Porsild to commence his paper.

Mr. Porsild then read the paper printed above, and a discussion followed.

The PRESIDENT: I should like to ask Professor Seward, Master of Downing College, Cambridge, and Professor of Botany in the University, to say a word or two. Many years ago he travelled in Greenland and knew Mr. Porsild's father very well and also his young son, our present lecturer. As you have heard, Mr. Erling Porsild's primary profession is that of botanist. He is at present in fact Professor of Botany under the Dominion administration.

Professor SEWARD: It has been a great privilege to have been allowed to hear this lecture by my old friend, Mr. Erling Porsild; I have learned much from it. Mr. Porsild has been talking of a country of which I know nothing from first-hand knowledge. I have never been much farther north in Canada than Ottawa.

I was particularly interested to see the pictures and to hear what Mr. Porsild had to say about conditions of plant growth. He did not tell us much about the botany of the country which he traversed, although I suspect that he spent quite as much time in looking for plants as he spent in looking after the reindeer.

When I had the pleasure of travelling with Mr. Porsild in Greenland fifteen years ago I was able to appreciate some of his many good qualities. I will mention only two. In the first place he is, as I found out then, an extremely competent field botanist. There are very few people who have as wide a knowledge of Arctic vegetation as he and, I may add, his father possess.

The second quality that I should like to mention is Mr. Porsild's sympathetic attitude towards the Eskimo and his uniform kindness in dealing with them.

I feel that you will agree with me when I congratulate Mr. Porsild on having most successfully carried out this great experiment. It was not merely an adventure in the ordinary sense. It was an experiment which I think there is no doubt will yield very valuable results, not only as regards value to the Dominion of Canada but particularly in improving conditions under which the Canadian Eskimo are living in those far northern regions.

As the President said at the beginning, it would have been difficult for the Dominion Government to have found a better qualified and more sympathetic leader to undertake this adventure than Mr. Porsild. I hope that in due course we shall hear something from him, probably in print, of the results of his botanical explorations, because I know from what he has told me he made a very large collection.

As a matter of fact we do not know much in detail with regard to the vegetation of that part of the world, and it would be interesting to learn what percentage of plants are more nearly allied to those on the western side and what percentage have greater affinities with the plants to the east. Every one who has any knowledge of Arctic vegetation is aware of the fact that a great many of the known northern species have a circumpolar distribution, but there are others which are confined to the western part or to the eastern part. On that latter question I feel sure Mr. Porsild will eventually be able to throw much light.

In conclusion, may I express my hearty thanks for the privilege of having been allowed to come here, and my congratulations to Mr. Porsild for the success with which he carried out this very difficult enterprise.

The PRESIDENT: We are glad to have again with us Colonel Vanier, who has been so good as to speak to us before in this Hall. As official Secretary to the High Commissioner for Canada he represents his Chief, and we should be glad if he would come and speak to us.

Colonel VANIER: It gives me very great pleasure to support the vote of thanks which has been proposed by Professor Seward. Unfortunately I am neither an eminent botanist nor an explorer; my only qualification to speak is that I happen to be a Canadian. I have been in London for about five years and I am beginning to think that the best way to keep in touch with Canada is by coming to the meetings of the Royal Geographical Society; not long ago it was to hear about the Ellesmere Land Expedition, and now to learn about the wonderful country from Alaska to the Mackenzie Delta.

I must confess that I feel a little ashamed of myself for having to learn about some parts of my country from people who were not born there. I hope you will not think that we are a dishonest race because we have stolen men, and such men as Mr. Porsild, from Denmark and taken, or rather I should say bought, reindeer from the United States.

I wish to assure you of something that you probably know already from having heard the lecture; we in Canada consider ourselves extremely fortunate in having

been able to adopt the lecturer who has spoken to us this evening. I feel sure that Mr. Porsild is only at the beginning of the valuable work that he is going to do for Canada. It gives me very great pleasure indeed, on behalf of the High Commissioner, to congratulate the lecturer and to say how proud we Canadians are of him, a Canadian.

The PRESIDENT: It remains for me to close the proceedings. I am sure you now agree with what I said before the lecture, that the tale we have been listening to treats of a most extraordinarily interesting episode and a most courageous experiment on the part of the Dominion Government. We can only hope that we shall hear as years go on that the experiment has fully justified itself; that the reindeer have found conditions in the new country propitious and will be able to multiply as in Alaska. If they do it will mean a great deal to the economic interests of Canada.

I will now ask you to join me in thanking Mr. Porsild, who, I may tell you, after having weathered those awful temperatures that he mentioned comes over here for a few weeks, strikes a spot of our worst weather, and becomes the victim of a touch of 'flu. That made things difficult for him, and we are the more grateful to him for facing his paper to-night and for the interesting story he has told us.

Let us thank him in the usual way.

KUHGALU: SOUTH-WEST IRAN

J. V. HARRISON

THE mountainous and relatively inaccessible country of Kuhgalu lies south-east of Bakhtiari Country and runs as a strip of highlands some 50 miles wide to the Bushire and Shiraz road. On the south-western side there is an expanse of broken foothills where red rocks and white gypsum build up a zone of low variegated difficult country, and on the north-eastern side the ragged irregular mountains of the watershed separate the several plains along the high edge of the inland plateau which constitutes the centre of Iran. Kuhgalu has an area of about 8000 square miles. The Khirsin, the largest tributary of the Karun river, the Marun, flowing not far from Behbehan, and the rivers Zuhreh and Shapur share the drainage with the Qara Aghach or Mund river except for a small part on the north-east edge which lies in the basin of the Rud Kur, a river discharging into the salt lake of Niriz, which has no outlet. The giants amongst a welter of considerable mountain ranges are Kuh-i-Khami on the south-west, Kuh-i-Alvarz in the central part, and the spectacular range of Kuh-i-Dina near the northern margin. These mountain fortresses have long been the home of a group of restless tribes, the Boir Ahmadi, the Mamasani, the Taybi, the Bahmis, and the Dushtmanziari, who have now been brought to order by the present strong Government under the control of H.I.M. Riza Shah.

During the season of 1933–1934 I spent nearly nine months travelling in, and geologically surveying, this district accompanied during a part of the time by Mr. N. L. Falcon and Mr. A. Allison, and for the last month by Mr. D. C. Ion alone. Our camp and transport was looked after by Mirza Nasrullah Khan Mustofi, whose valuable services resulted in the smooth running of the expedition, and whose many prudent hours of road-making led to our one hundred and sixty camp movements being accomplished without any loss of life to the forty mules which formed our caravan. The whole area was mapped on a scale of 4 miles to the inch by plane-table facilitated by the use of 80-cm. Barr and Stroud rangefinders, and control was afforded by points fixed astronomically, using wireless for time signals, by Mr. W. E. Browne. Some conception of the dissection may be formed from the fact that in the course of the journey I climbed approximately half a million feet up and down.

Very little has been written about the geography of Kuhgalu although it has been crossed by several travellers. Stocqueler and de Bode completed journeys through it nearly a century ago. Mr. R. S. MacKilligan with colleagues and Mr. S. Clegg of the Anglo-Iranian Oil Company's staff saw much of it in 1923 and 1924, whilst in 1926 Mr. C. Jennings and Mr. K. W. Gray passed through from Falat to Behbehan. Formerly the presence of turbulent tribes rendered regional survey, such as has now been accomplished, out of the question, because the ridges and commanding peaks (most of which we climbed and used as plane-table stations) were in "no man's land" between the demesnes of rival clans where no one would have been safe. To-day

Kuh-i-Dina, with dust rising during rock falls

The 1933 landslide on N.E. flank of Kuh-i-Dina; scar on the left; debris tongue in the foreground

Kuh-i-Dina from near Kakan

Talaspid village around a tumulus

security such as has never been known before prevails in Kuhgalu. Even into this region of mountainous strongholds and formerly unruly tribes, the strong hand of H.I.M. Riza Shah now exerts authority—truly a remarkable achievement.

The plan of the survey which occupied from the end of September until the middle of June was arranged to commence and end in the high north-eastern part of the area and to leave the lower south-western part for examination during the winter. The journey for convenience may be considered in stages from point to point.

Ganduman to Simarun

Motor transport is available from Isfahan to Ganduman. The latter place was already astronomically fixed and beside its ample springs the caravan assembled. Two short moves away to the east we passed the shrine and village at the limit of Bakhtiari country, where the peasants at the beginning of October were still threshing and winnowing their crops of wheat and barley, and entered a high, gently-undulating, treeless plain uninhabited in winter but serving as summer quarters for the Qashqai Turk tribes and providing sufficient grazing for their flocks and herds. It is well watered by springs which feed one of the branches of the Karun River. On the north of it dark rugged ranges *en échelon* rise to a bold cockscomb ridge, and on the south gentler slopes of light grey rock are crowned by a broad smooth summit lofty enough to overlook much of the northern districts of Kuhgalu. North-westwards seen from this top blue peaks in Bakhtiari country formed familiar landmarks, as did Kuh-i-Wanak, a bold pyramid in the middle distance, standing like a great boundary mark on the tribal frontier between Bakhtiari and Qashqai lands. An elongated elliptical depression lies between Kuh-i-Wanak and our view-point, from which the drainage escapes through a gully in the ridge joining their south-western flanks. Westward and south-westward the mountain falls away gently at first, but then steeply in a long line of cliffs extending south-eastwards. Below them lies a valley with a few patches of cultivation struggling to make a show against the background of naked red rocks. They are covered by a pile of brown conglomerates eastwards forming a steep mountain, but southwards the land tilts upwards and the white slopes lead up to a rocky plateau obscuring further landscapes in that direction. From a south-easterly summit on the same range, which becomes a knife edge in this direction, the Simarun plain comes into view.

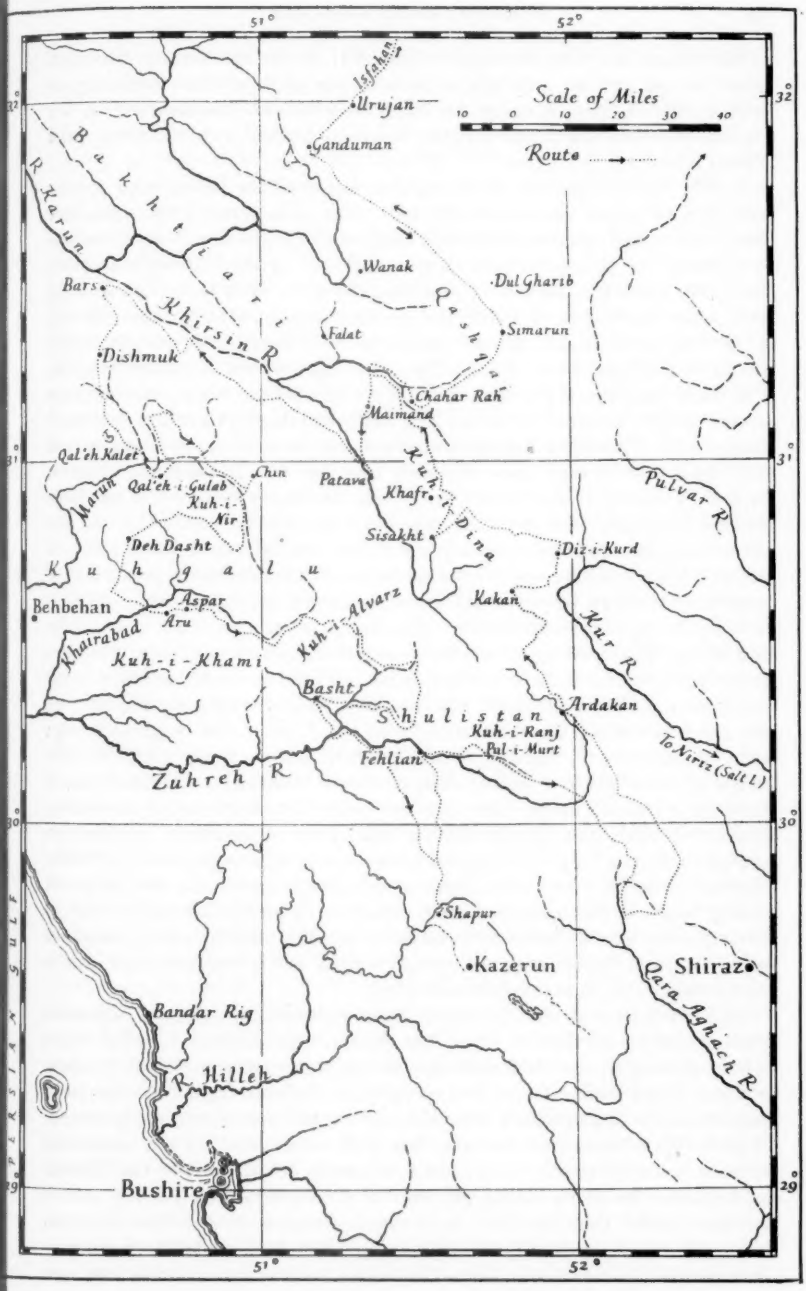
The escarpment below us bounds this plain on the north to which access is provided by three deep gullies leading down from the high plateau under the dark comb of Dul Gharib. In the eastern one only a rough footpath exists. In the western one there is a somewhat better track passable for the tribes and lightly laden animals. But the central one is traversed by the well-used caravan road from Behbehan to Isfahan, which Stocqueler followed more than a century ago. It is sufficiently wide for some venturesome drivers who occasionally coax taxis as far as the village from Isfahan. At the foot of this central gorge a copious spring is situated from which the town is watered by a system of small canals or *jubs* led from terrace to terrace, through the houses built crudely of mud and undressed stone, across the narrow lanes

which thread haphazard between the dwellings to the gardens and cultivation upon the plain beyond. From a little distance the scene is charming especially in the autumn when the tints of the poplars and the fruit trees are at their brightest, and the apron of tillage below the town is variegated by the rich browns of fresh ploughing contrasting with the golden stubble of the past season's crop. After travel over the treeless plateau to the north, the vista of this fertile oasis bursting suddenly into view, gives a thrill. As it stands guard at the portal of the only easy route from north to south, its strategical importance must have been great, and its control a source of wealth, for it is a natural toll-house. Now a police post keeps an easy check on tribal movements, and its merchants profit by the custom of the wayfarers.

The bulk of Kuh-i-Dina assumes imposing proportions from Simarun southwards, and its many peaks stand as jagged teeth against the sky. By October it appears as a series of bare sheets of brown and grey rock sloping north-eastwards, with a few small patches of snow left lodging in the deeper crevices, where the shade is deepest. The small amount of snow remaining in the late autumn upon a range rising to nearly 15,000 feet is noteworthy, and indicates that, as observed in Bakhtiari country, the permanent snow-line on the northern slopes of the mountains is somewhat above 14,000 feet. Avalanches in winter are not uncommon, but no glaciers were seen. The landforms on the mountain top appear to be due to sub-aerial denudation of the sedimentary rocks of which the mountain is built.

Simarun to Patava

Going southwards from Simarun we crossed the gently sloping plain extending to the foot of a dark, bare, rounded mountain over the back of which the road passes. On the right the ground rises to the base of a long line of white cliffs set out in bold bluffs, between which chimneys have been weathered, up which it is possible to scramble. This escarpment runs off into Bakhtiari country. On the left there is an ancient lake terrace and behind it, in the distance, another gentle broad-backed mountain. All this country region is uninhabited except in the spring. While the caravan must follow the road over the hump ahead two alternatives are available to those on foot. One is a narrow path along the lip of a gorge cut down 3000 feet by the stream from Simarun, and the other a wide track through a dry defile somewhat more to the east. A stream flowing from the east at first flowed through this dry gorge but a tributary working along the foot of the range from the Simarun stream intercepted it and now leads it to discharge into the Simarun water just before this enters its gorge, Tang Au: the watered gorge. This name contrasts with Tang Khusk to the east: the dry gorge. Across this barrier we reached a high open valley which apart from subsidiary ridges standing in it runs away to the south-east along the northern base of Kuh-i-Dina. Followed in the other direction it rises to a small plateau from the edge of which a line of sheer cliffs fall away to the well-watered, fertile Falat plain, the granary of high Bakhtiari country in the east. A village stands on a subsidiary stream flowing eastwards to the river collecting from the north and east, under the slopes of Dina and is named Chahar Rah to indicate that four roads join here. It once had a small fort, as indeed had most


51°
52°
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Isfahan
Urujan
Ganduman
Scale of Miles
10 0 10 20 30 40
Route
Bakhtiari
R. Karun
Wanak
Dul Gharib
Bars
Khirsin R.
Pashaï
Falat
Simarun
Dishmuk
Chahar Rah
Maimand
Qal'eh Kalet
Marun
Qal'eh i Gulab
Kuh-i-Nir
Chin
Patava
Khafr
Kuh-i-Dina
Pulvar R.
Deh Dasht
Sisakht
Diz-i-Kurd
Kuhgalu
Behbehan
Aspar
Aru
Kakan
Khairabad
Kuh-i-Alvarz
Kur R.
Kuh-i-Khami
Basht
Shulistan
Ardakan
Kuh-i-Ranj
Pal-i-Murt
To Nirriz (Salt L.)
Zuhreh R.
Fehlian
Shapur
Kazerun
Shiraz
Qara Aghach R.
Bandar Rig
R. Hilleh
Bushire
PERSIAN GULF

of the villages scattered throughout Kuhgalu. In the late autumn they had honey to sell, and we were able to secure some 50 lb. of this commodity of good quality. Grain for the mules was a more difficult business and, as we stayed more than one night, supplies had to be fetched from the prosperous Falat plain.

A little to the south the combined drainage from the basins lying north-east of Kuh-i-Dina breaks through that range in a grand gorge 5000 feet deep, cut in solid limestone with wild crags which render it quite inaccessible. It is incised in the north-western plunging nose of the Kuh-i-Dina chain. Evidently when the channel was initiated the river must have been flowing in a valley south-east of which the primitive range of Dina rose. On the north-west some higher ground must also have risen, otherwise the river would have slipped down the shoulder of the mountain it at present notches. The water has gnawed 5000 feet through the rocks of the range, and the cover of young rocks which in the early phase controlled the river's course, has been stripped off. The early topography on which the course of the river was started was like a flesh-clothed body of which time has now left only the skeleton behind. The western lip stands some 10,000 feet above sea-level. From here we look back upon some of that open gentle country to the north, bare but for patches of grass and thistles now burnt yellow; below us gleamed a reach of the river hidden at both ends by the overlapping cliffs; and to the west a wilder country covered by woods of oak in contrast to the treeless north. Altitudes in both directions are comparable. The change is not natural but man-made, and marks the retreating strand-line to which the waves of charcoal burners from the distant towns have reached. The road crosses the divide lower down and descends steeply amid the oak trees to a ford below the great gorge. In the parched autumn the river, now called the Khirsin, can be crossed with ease, the water barely reaching the mules' girth, but for three or four months in the spring a *kilik* is required, while the beasts must swim. Downstream it flows in a bed no longer deep, for the rocks it cuts are softer and easily weathered back, but nevertheless at one point it suddenly narrows so considerably that a primitive wattle bridge serves to pass the summer traffic dryshod from bank to bank. Close to the stream below the bridge a salt spring issues on the right bank from mounds of purple shale and a crust of white glistens on a fan between it and the river. The salt with these variegated rocks contrasts sharply with the normal browns and is incongruous with the surroundings. Such is the Falat salt-plug.

On the left bank at 1500 feet above the river stands the village of Maimand commanded by an old fort whose last chieftain was a victim of tribal feuds a long generation ago. It stands on a minor stream draining from the base of Dina. A few fields watered by a spring yield the grain crop. Near the river some terraced flats provide a little rice and, for the rest, acorns are garnered. A wide-topped mountain hems in this little community on the south and extends north-westwards a few miles to the gorge cut across it by the Khirsin as it pursues its course across the grain of the country after flowing with it for some miles from the ford we crossed. Gorge scenery below becomes wild and barren again. Beyond it the range continues in Bakhtiari country surmounted by several huge natural fortresses, each a coral island of long ago,

pyramids on the old sea-floor. They form a unique feature in all this region and probably in Iran.

Traced eastwards this wooded range merges into a wild tilted terrace falling gently and with wonderfully even grade from the southern cliffs of Dina to the river, draining a belt of country in front of this giant chain. The terrace is composed of gravel now firmly bound together and marks the fans made by short streams which raced from the mountains' front after the heavy rainstorms and soon laid down their much too weighty load. Across the tableland, drainage from the mountain now follows a few channels cut 1000 feet or more below its surface, and near them rare patches of soil form the farms which a scanty population cultivates. Near the river, which keeps closely to the southern limit of the former trough and drains a basin south of Kuh-i-Dina, the tilth is wider and a few villages and forts testify to better conditions. There are ruins of bridges and of forts which may date back to Sasanian or even earlier times. Patava is now the best preserved and most important village of this part and stands near the river's edge, while cultivation extends sporadically downstream until this river joins the north-eastern drainage from Dina, the Khirsin river, and the united waters enter another gorge to the west. Unlike countries where maturer topography has been developed and where the river valleys afford the easy and obvious major routes, in Kuhgalu a road can hardly ever follow a river closely. The occasional wide open parts of a valley and rare alluvial plains are surrounded by mountains, through which the rivers break in narrow gorges where the walls are often too steep for a daring cragsman to negotiate a passage. The cultivated basins strung out along the river must be reached by easier but hilly routes sometimes deviating one or two ranges away from the watercourse.

Patava to Bars

Such was the hilly road the caravan had to follow from Patava, up minor streams, to cols which it crossed between limestone mountains. Twice it had to surmount a hog-back range, flat on top but with alarmingly steep flanks, and to pass over smooth slabs of rock providing precarious footing for a laden mule. In October much of the country was empty, for the tribal people had left this region, in which each morning we experienced a frost, sometimes as much as 10 degrees. Meagre fodder for the animals was provided by what remained of the grass, but barley, which working mules are given except in the spring, had to be carried at times. The scenery is superb. From a commanding hill top like Putab the landscape is full of variety. The first impression is that of great depths. Scoured troughs lie between the great, rounded, rigid rollers which trend as regularly as waves driven by trade winds. Any trace of monotony is swept away by the varied forms and colours laid bare where the waves have been broken by the transverse cuts made by a stream tired of its easy trough, and seeking the river through a ravine across a range, or by the valleys of decay eaten back along a mountain crest. The colours are as varied as the shapes. Brown and rusty coloured limestones predominate, but here and there in a trough lies a patch of white gypsum, whilst in a corrie-headed valley sage-green and deep-red rocks repose one upon another.

A few small villages are ensconced in the valleys between the road and river.

These permanent settlements are set beside water, and the flat-topped houses which serve the pastoral requirements of their owners cluster on a bank with a southern exposure. In late October a large part of the population was found high up on the mountain side, bivouacked under crude arbours of leafy boughs harvesting the acorn crop. The area of arable land, in much of this part of Iran, is insufficient to provide wheat or barley enough to feed the population, which, sparse as it is, relies in varying proportions upon the acorn harvest for its means of life. There is a steep ascent to the last col from which the Bars depression is visible. A fort, in a condition of disrepair, still stands amidst an area of cultivation. This district is known as *garmsir*, *i.e.* the warm country in which the nomads used to winter when driven out of the mountains by rigorous climatic conditions. Near by the Khirsin river emerges from its gorge and flows in a fairly open channel to join the Karun. In November 1933 preparations were in being for a new telephone line across the hills, and dressed poles of local timber were being floated down the Karun, this being much the simplest method of transport from the woods where they grew. From here they were being distributed along the projected line by donkeys. Around Bars there are terraced fields where rice is grown. From these a welter of low red hills rise up and extend some distance north-west along the right bank of the Karun.

Bars to Qal'eh Kalet

After Bars we climbed out of the depression, over the watershed to the south, and in the course of the journey crossed three ranges before dropping down into the wooded valley at one end of which stands the fort of Dishmuk. The Khans of this place took an aesthetic interest in trees, as a result of which a few fine specimens are preserved within bow-shot of the fort, and show what trees can become if well tended, or perhaps if only not molested. In November black tents were pitched on the lower slopes of the valley amongst the woods. On this side most of the acorn-gatherers had returned from the hills, where we disturbed rooting pigs and saw an occasional bear shamble off at our approach. Dishmuk was the first of the Kuhgalu forts we saw. It is an imposing structure, but vaguely reminds one of the simpler type of ferro-concrete building. In all these forts however gypsum is the material the builders use to produce their angular and perpendicular effects. Such forts are a great contrast to the Bakhtiari type, which is essentially four stone walls with bastions at the corners. The Kuhgalu type is a tower with walls too smooth to climb, of little beauty but impressive and at one time of considerable use. Prongs of limestone, each a mountain, reach down into the Dishmuk valley from the north-west. The stream cuts through them in deep gorges of incredible narrowness. Camp lay about 2 miles by stream and 200 or 300 feet below the mouth of an inaccessible gully in the northern side of the mountains. To reach camp a climb of 3000 feet and a tramp of 12 miles was involved, while the stream cut through two knife edges in *tangs* and crossed the decayed cavity between them.

For 40 miles south-east of Dishmuk the valley runs parallel with its even limestone walls. That on the south is a particularly fine example of a naked rock whale-back range, a smooth curve rising gradually from each end to a

gently domed summit half-way along, reaching 9000 feet high. The Bahmi tribe used a road at the north-western end of this range which served them to cross the grain of the country with the changing seasons. The Dushtmanziari tribe had a road at the other end, and had for neighbours the Boir Ahmadi tribe with a parallel road half a dozen miles farther south-east. Between the tribes there were at times no friendly communications. To act as a buffer, and to enable them to till the arable land in between, imported *saiyids* have built little villages each with its tomb to augment the personal sanctity of the inhabitants and render them all but inviolable to the superstitious but predatory tribal people. The *saiyids* maintain friendly relations with mutually aggressive factions. Such a system of *saiyid*-held land between neighbouring clans was practised in Kuhgalu, until recently. At the other end of the valley stands Qal'eh Kalet guarding the gorge through which the Marun river flows to the plain. The road cannot follow the river but climbs to the col over smooth slabs. A ruined bridge and cobbled track zigzagging up the hillside show how keenly the value and need of communications were appreciated, in perhaps Sasanian times. An alternative route runs through a deep gully to the south-east, guarded by a fort built upon a high terrace of the Marun river. The main Boir Ahmadi tribe used this road, and we met a section of them moving down along it, driving their flocks, late in November.

Qal'eh Kalet to Chin

As good weather continued we turned back up the north-east side of the Dishmuk valley and followed the Marun along an extremely bad path below picturesque crags on the one hand, and a gentle smooth rock slope on the other. The river then turned off on our right hand, cutting deep gorges, while we sought a route leading over a steep bare hog-back called Kuh-i-Barfi. The road was so steep that only after considerable repairs had been made could our caravan negotiate the crossing at 9000 feet. On the pass snow lay ahead on the north slope, but behind was the wooded valley with a southern aspect we had travelled through: a district which was a complete contrast to the undulating treeless plateau flecked here and there by streaks of thin snow which lay ahead. Across this uninhabited, inhospitable region we travelled fast to the south-east, doing 26 miles in the move in order to reach a water supply within a day's march of Chin. We camped where a mountain rose 2000 feet behind us, our tents pitched close to one of the crude tribal bough villages now deserted. On the last night of November a storm broke upon us, and levelled some of the tents. Snow fell at 500 feet above us and in camp at over 7000 feet above sea-level. Conditions were most uncomfortable.

From this camp we at length moved on over a high pass and down a valley the upper part of which was deep in snow, to the village of Chin. Kuh-i-Mim, so called from its resemblance to the letter *mim*, and two other bold narrow mountains enfiladed the valley, which lies between a rounded hog-back range on the one hand and a cockscomb ridge on the other. The Marun cuts across both in inaccessible gorges. To reach the upstream side of the gully only 2 miles above Chin a detour taking six hours was needed, and then we were in another lateral valley bounded by a rugged gorge-cut range on the

north-east, beyond which the river enters the upland plain in which its source lies, a grassy plateau uninhabited throughout the winter. Chin was the headquarters of the Tamaradi branch of the Boir Ahmadi tribe, and we met the chief who paid a ceremonial call to our camp. Most of the tribe with its flocks and herds we had met *en route* for the low plains where they winter, but a group of them remain in the village to guard the crops, chiefly against marauding pigs. Chin is tucked away amongst the mountains and in the past was as inaccessible as any shy tribesman might desire.

Chin to Aspar

From Chin we turned southwards. Our next camp was among the oak trees on the north-eastern side of Kuh-i-Nir, a lofty range which brought much precipitation down upon us. It was three days before the weather was sufficiently promising for us to make for the col at the south-eastern end of the mountain, the direction in which we wished to travel to the lower country as the course of the Marun, which cuts first this range and others to the south-west in deep gorges, offers no satisfactory route. The col on the south-east of the mountain at a little over 8000 feet was the edge of a snowclad plateau. Our guide tied goat-skins to his feet with the fur inwards, an interesting case of the use of rough mocassins in snow. The ordinary *givas* with their cloth soles and uppers are quite unserviceable in such conditions, but for want of better were worn by most of our men. In dry snow tribal men will often discard *givas* and travel barefoot.

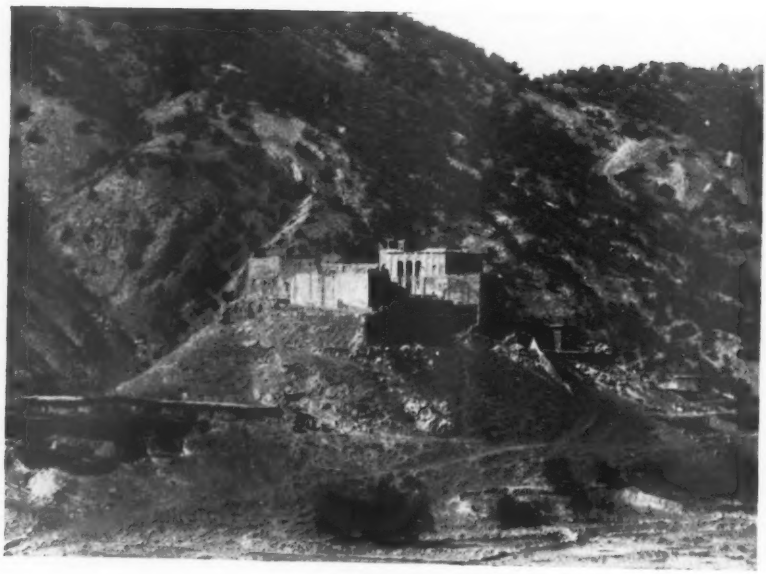
Two prominent ranges run off south-eastwards from the ends of this platform, which slopes imperceptibly south, so that the snow passed into mud before we left the open upland for a steep stream bed following the soft zone formed by the marls enveloping the limestone mass of Kuh-i-Nir. After another move downstream in a general westerly direction along an important tribal track we debouched from a canyon nearly 1000 feet deep in which a toll-exacting hermit tends a tomb, upon a small plain amongst the hills. A little cultivation is possible here, which is the reason for the existence of a few small villages of the usual flat-topped houses. Between the stream and Kuh-i-Nir on the right-hand side uneven low hills at first give way to a wide rock terrace upon which masses of debris, made up of fallen material of all sizes from pebbles to large angular blocks more than 20 feet cube, lie under the mountain slopes in irregular hummocks. Among the hummocks are flat-bottomed, soil-filled depressions, the site of ponds formed by the initial chance drainage of the rough landslide. A conspicuous notch high on the smooth slopes of Kuh-i-Nir draws attention to where layers of limestone have fallen off the mountain-side to produce the confusion below. Amongst the dry ponds, and over the hummocks, the tribes were grazing their herds tended by small boys and peculiarly vociferous dogs.

Towards the main stream the rock terrace is cut by deep canyons which run in such straight courses that it appears to be evident that jointing in the rock directed the early inroads of the drainage. The southern edge of the plateau is puckered into a sharp narrow ridge, and then falls away over a flank of rock slabs to the stream below. A chasm provides the gateway from the mountains to the plains of Deh Dasht for both men and water. Tribal

Basht from N.W.

Simarun from above

Diz-i-Kurd



Dishmuk

chieftains maintained forts wherever there was water near the edge of this plain. Most of these are now ruins and their owners elsewhere, one of the changes effected by the Government in its work of providing security. Standing near the middle of this plain is the town of Deh Dasht. It is marked on the maps. Our men made inquiries from the guide about its resources. Had it a bazaar? Was the bath good? His replies were vague but had not prepared us for what we found. We followed a path over the plain running near to a *qanat*. This led to a ruined fort and an old arch aqueduct, also broken down, so that the water from the *qanat* returned to the stream. From here we could see the town and were surprised to see no people, as from a little distance the buildings appeared relatively sound. The place bristled with shrines, upon which the cupolas are still embellished with symbols of fertility. But as we entered its streets we saw beyond doubt that the place was entirely deserted. At close quarters its houses looked no worse than they did in Behbehan as I knew it in 1919, but here stands an abandoned town. Probably when the *qanat* broke down there was much tribal bickering and caravans coming in from Behbehan may have experienced even greater vicissitudes than usual, causing merchants and mullahs to withdraw. This town may possibly date to Safavid (Shah Abbas) times, but ruins of much greater age are common amongst the valleys from Behbehan to Basht, and mark occasions when tranquillity prevailed and agriculture expanded. The former condition has now recurred; the latter may be expected to follow.

One stage from here over broken gypsum hills brought us to Aru. The gypsum of this plain has been smoothed off so evenly that it recalls a plain of lateral erosion. But the difficulty is that such plain surfaces occur at more levels than one, and are not placed in such a relationship to one another that they can be attributed to successive terraces on the side of a former drainage. The plains are not structural, for they do not conform to the bedding of the rocks, and so while the cause of this remains doubtful, it leads one to speculate whether the reputed plasticity of the gypsum rock series may not have allowed a plain of lateral erosion once formed to move unevenly under the load of small ranges of rocks younger than the gypsum series. These terraces are now eroded by intricate youthful stream courses which discharge in the Khairabad river flowing some 500 feet below the highest gypsum plane. There are the ruins of an old village near Aru, and a little farther east there is the present one grouped around a fine specimen of a Kuhgalu fort. A route leads south-eastwards into wild country forming the foothills on the southern flank of Kuh-i-Khami. The dissection reaches close upon 8000 feet. Kil Kard (the knife edge) is perhaps the most impressive range and lies about 12 miles off. On the crest of the last subsidiary range a few miles south of Aru the Khan of Aru had built his summer quarters, nearly 5000 feet above sea-level, looking out over the Behbehan plain 4000 feet below to the west and at the stern massif of Kuh-i-Khami to the east.

North of Aru stands Aspar, the abode of an elder but unimportant brother of the Khan of Aru. It is a village with an old fort perched high upon a crag, and its natural strength is augmented by walls which would seem to have made it impregnable before the days of artillery. Extensive caves honeycomb the rock, and water is obtainable from a well, so that stocked with fodder this

rock could have stood a siege, housing men or animals. It stands at the western end of the high range of Kuh-i-Khami somewhat above the level of the Deh Dasht plain. From the village rises a semicircular range seared by countless rills and known in consequence as the Hill of a Thousand Valleys, forming a rampart encircling the main mountain mass. As evidence of how times have changed the laird of the village requested a photograph of himself, son, daughter, and wife.

Aspar to Basht

After leaving Aspar and skirting the end of Kuh-i-Khami we reached the valley lying between it and its next big neighbour to the north-east. For a time a river runs along this, but it soon forsakes the broad trough between the mountains and cuts straight across the ranges to the north-east in gorges reaching a depth of 5000 feet. We camped at Christmas at the mouth of the first of these, with Kuh-i-Khami to the south-west of us behind two girdling ranges of foothills. The first is traversed by a very straight water-cut *tang* which permits unshod animals to make their way through to the first moat. A more normal and less direct stream-bed leads through the second range to the base of the main mountain itself. This inner moat is well wooded, and in it stand a few small villages.

The structure of this mountain mass is that of an onion of three skins. The two outer ones are unevenly worn off and make up the foothills. The rocks in the outer skin at one place have turned over in an extraordinary flap which is resting now on the valley floor, forming an outlying exotic range nearly 3000 feet high above the stream. Such an exceptional morphological effect has only recently been recognized, and this is a typical instance (*Geol. Mag.*, vol. LXXI, pp. 529–539, 1934). On the other side of the valley, up the river gorge to the north-east, a footpath of a kind exists. It involves frequent wading and some precarious jumping from boulder to boulder, many of these being over 10 feet in diameter and polished. The reason given for such a path being known to our guide was that it was a hunting path. Instead of going direct along the valley to Basht, we took advantage of a spell of good weather and crossed the range to the north-east, climbing its 10,000 feet summit on New Year's day. This mountain is Kuh-i-Alvarz. It commands a superb view across Kuhgalu, for it is almost pyramidal in shape as it stands here, cut by the gorge on one side and plunging gently on the other. Across the high upland of rolling hills to the north-east we could see the whole length of the Dina range with lesser ranges in front of it, and in the other direction at this distance the grandeur of the Khami range could be grasped.

Even at this unseasonable time we did not have the mountain to ourselves. On the way up we came on an overhanging boulder with a smouldering fire below, but the hunters whose camp it was had evidently seen us coming, and following the usual practice of these people were giving strangers a wide berth. We camped at the south-eastern plunge of this range at over 7000 feet above sea-level, and fortune favoured us for the snow did not come until we were in lower regions. On the steep south-western flank of Alvarz we saw the King's Cave. This is a deep cavern 140 feet above the foot of the cliffs, up

which we were unable to make our way. We could see from below that a considerable amount of brickwork still stands in the cave, which might perhaps be entered from above and, given the time, would doubtless provide the subject of interesting research. The northern face of Kuh-i-Alvarz is fantastically etched and fluted, owing to uneven solution of the rock slabs by the water draining away from beneath the melting snow in the spring. At its foot runs a broad trough in which are a few tombs and small villages. At first glance this broad, smooth valley appears to be an easy route to the south-east, but its superficially smooth form is so fretted by the incised drainage that it makes it impassable for animals, and we had twice to cross a difficult ridge on its south-western side to reach its mouth, before going farther north-east up a deep gorge called Tang-i-Tamaradi into the country near the summer quarters of the tribes.

Hill partridges locally known as *kabk*, the Himalayan *chikor*, abound in all the mountains of Kuhgalu. They are hard to shoot, as they run in preference to rising. The tribes people hunt them from the shelter of a *daftak*, a dull grey cloth sheet about 7 feet square, decorated by tufts of parti-coloured cloth. A peep-hole through this enables them to see the birds, which allow a *daftak* to approach quite close to them without taking alarm. They also trap the birds, making use of the knowledge that *kabk* run rather than fly. With thorn branches, the stems of which point uphill, they build a low fence about a foot high and perhaps half a mile long, or even more. At intervals along this zareba they leave gangways paved with stones which lead up as gentle ramps to a small pit covered by a simple spring trap-door supported by a twisted goat-hair cord. It collapses under the weight of the bird, which falls through into the pit, after which the door regains its former position and the bird is caught. Snow fell around our camp here at 5000 feet, but we continued on a circuit to the south-east and made an attempt to surmount the 8000-foot edge of the plateau to which we came again in the early summer. Clear atmospheric conditions rewarded our heavy ascent through the thick soft snow to the edge of the escarpment. The caravan crossed a snowy col and pitched camp just below snow-line on a stream draining through the opposing and southern ridge. With this on our right hand we travelled farther east to a stream-course down which a practicable mule road ran to debouch upon the plain of Shulistan, where sheets of soil lap water-like against the rock walls of the mountains. This has a drowned topography in which the rock structures no longer manifest complete control of the shape of the hills and valleys. Villages are fairly numerous. Some are built around old tumuli, while the relics of old fortifications can be made out upon the crags of sundry *inselbergs* rising from the plain.

The Shulistan plain is bounded on the north-east by the ranges amongst which we had been travelling, and on the south-west by a dark range cut across by the Zuhreh river in the centre, and skirted at its north-western end by a tributary of this river once crossed by bridges, of which the remains show that three were built at different times over the same favoured place. Besides the bridges there remains an old rock-cut canal, engineered along the limestone overhanging the river. The size and finish of these bridges is of a different order to the irrigation works accomplished by the tribal people. There is a ford at this spot and the alignment for a new motor road has been made to it.

From the river a wide structural valley opens out and the castle of Basht stands in its midst. This has been the scene of some grim tribal history, for à parallel to which we may turn to Stirling Castle in the Middle Ages. While we were near Basht in the latter part of February an unusually severe snowstorm swept the country, and snow lay for a few days at this low level. Snow-bedecked to its base the neighbouring pile of Kuh-i-Khami, gleaming in the light of a full moon, formed a camp background not easily forgotten.

Basht to Shapur

A gully on the south-western side of the Basht valley leads to the plain below to which the core of Kuh-i-Khami plunges. It provides one of the main routes out of Kuhgalu to the foothills and the coast. Going south-east from this road we followed a terraced valley on the south side of which springs rise, marked by thick growths of myrtle, which provide relief of green to the predominant browns. The united waters of the river Zuhreh nick the remnant of the range in a narrow gorge and plunge into a gully on the south-west, the last obstacle between it and the foothills. The ford across the river to the south-east makes use of narrow gravel ridges between pools of deep water, and leads into a stretch of broken country. In this, during February, we came upon black tent encampments of the Qashqai tribes who winter here. Upstream the river debouches from the heart of the north-eastern mountains to flow for a time through a plain with three notable terraces above it, which mark positions at which impounded waters were once held before they cut some barrier down. A tributary however follows an easy course along the grain of the country from the south-east, and its valley affords such easy going towards Shapur that a car road has been brought through with little road-making. On this route there are tokens of past peoples: tumuli, towers, and carved panels. Near the tumuli in the southern range there is a deep gully called the Dragon's Den, and a story has it that the dragon was duly despatched by a local St. George.

A route alternative to the motor road runs farther south through easy valleys between gently-contoured, wooded, limestone mountains which on the north of the track rise into the sharp peak of Parikadun, overlooking the northern end of the Kazerun plain. The caravan followed it and climbed down over a steep hillside of gypsum. About 4 miles on we come to the stream rising in springs under the well-known panels of Shapur. On the right bank of the watercourse, but farther upstream, is the cave which houses the fallen statue of Shapur, and within is a fantastic grotto of stalagmites. Where the river leaves the mountain side for the plain a number of deep canals have been dug to water distant fields. They pass through the old ruined town of Shapur, the moat and walls of which can still be distinguished from the crumbling fort perched in isolation on a crag on the left bank of the river. The motor road from Bushire to Shiraz passes near by and its route, along the old caravan road, has often been described.

Shapur to Ardakan

On the north of the Shapur range runs a wide open valley flanked by a long range of hills, on the lower slopes of which vineyards are cultivated and

Ford across the river Khirsin

Crossing Kuh-i-Barfi

Vista from Balaga southward

Cliffs N. of Kuh-i-Alvarz

Tang-i-Tasar

orchards of pomegranates and figs are tended. Above these a rough tribal path unfit for a caravan leads to the escarpment top to which our survey took us. Beneath the snowy crag upon which the plane-table was set up we noticed in a crevice the skeleton of a small boy. What mischance had brought it here is not known; but in a country where it is seldom easy to procure an authentic or reliable name for a ridge, we could not resist the temptation to refer to this as Skeleton Ridge. On the edge of the valley beyond Shapur we found a group of oddly shaped hills again produced by the extraordinary turning over of a flap-like sheet of rock 1000 feet thick. We followed the motor road along the north-westward extension of this wide valley until it led us back to a broad plain through which the Zuhreh river flows in a broad shingle bed. Then we took to the hills out of which the river flows. Its deeply entrenched course was unsuitable for the caravan, which detoured and had to climb 3000 feet over a gently moulded hill, and fall nearly as much to reach the branch of the river on the south side of the imposing range of Kuh-i-Ranj. Nearer its source the river cuts through the chain in a splendid gorge. A rough footpath climbs its shoulder and skirts the edge of the cliff to the northern flank of the range where the river breaks up into four torrents rushing down regular lateral valleys gouged out of softer strata parallel to the length of the range. A minute village is settled here, and not far off stands a tomb which provided fancied security in case of need.

Moving south-eastward from this gorge we came to the place where the river turned to flow west, where it was crossed by an ancient bridge of which two arches and the Serai near by are still standing. The graveyard situated close to the banks of myrtles from which the bridge takes its name, Pul-i-Murt, is notable for an unusual type of memorial. The tablet is housed as the back wall in a brick shelter and on it no mean artist has painted in lively colours an equestrian picture of the departed. Unlike their neighbours the Bakhtiaris, whose favourite tombstone is a carved lion gardant, the Kuhgaluis seldom commemorate their dead by a handsome monument. Hence this one is all the more striking. The direct road from the bridge follows up the drainage north-east and crosses a low range on to the Ardakan plain, but our caravan bore south-east and climbed out of the valley on to a swelling upland south of this, standing between the two principal branches of the Zuhreh. A low chain of hills runs along the south of this upland, and beyond them is the deep channel of the river. A good view is to be had from this eminence of the eastern district, over much of which relics of a deeply stream-cut, tree-covered plain are the feature which attracts the eye. It is made up of lake deposits which are 1500 feet thick, and marks the site of a great lake which flooded an expanse of territory already deeply eroded by an ancestor of the Zuhreh. Damming of this river by faulting impounded the water for a time, but it has long been drained. The Ardakan plain just to the north is also part of this flooded district, but at a time when the flooding was still more extensive.

The hills rising in the south of this old lake are locally cultivated and vineyards with a northern aspect cluster around a few ensconsed villages. We moved from the south-western to the eastern margin of the lake in one long move, and camped on a plateau beside three reed-fringed ponds on the watershed between the Zuhreh and the Qara Aghach which flows far to the eastwards

Tang-i-Tasar
Cliffs N. of Kuh-i-Akwarz
Vista from Balaga southward

before crossing the ranges to the Persian Gulf below Bushire. The origin of these ponds upon this soil-covered plateau at 7000 feet above sea-level is imputed to blockage of earlier swallow holes. The rocks below the detritus are largely gypsum, on plains of which swallow holes readily form. In time the channels of these become blocked by rock falls and in the surface cavity a pond forms. Sediment falls to the bottom and protects the soluble gypsum from fresh solution. We camped here on March 21, the New Year's Day in these parts, which is always observed as a holiday. Presents are given, formal visits are paid, and compliments passed. Being away from the haunts of men our staff was regaled with a banquet of mutton, rice, and tea, after they had spent the morning at impromptu sports. The journey from here to Ardakan can be accomplished easily in three days' march across the plain in a fairly direct line, although zigzagging as we did it took us six weeks. Ardakan is a considerable village at the base of a fine rounded range. It is watered by a good stream which a few miles below the village leaves its valley and flows across the plain to the south, eventually cutting across the lake beds as the Zuhreh river. The summit of the range, nearly 4000 feet above the village, is not a good view-point because a higher ridge runs behind it, and to the north-west still higher humps occur. Over the western hills between Shiraz and Ardakan we can see, but their rounded form is not imposing in spite of their height of 10,000 feet above the sea, and of over 3000 feet above the adjoining plain. South-westwards a series of crowded wave-like ranges succeed one another to Pul-i-Murt and plunge gradually below the margin of the old lake to the south of us. Clusters of small houses are scattered near the stream across the plain and the amount of arable land, much of which is irrigated, is considerable. A tolerable motor road, which is open except during spells of bad weather, runs to Ardakan from Shiraz.

Ardakan to Sisakht

This journey can be effected rapidly during the summer and autumn, as a motor road has been engineered to the new town Tul-i-Khushravi, which is the centre of administration for Kuhgalu. From Tul-i-Khushravi to Sisakht can be covered in two easy caravan stages. For us the journey was one of a month's duration, as we toured the mountains to the south-west and then east of Sisakht before reaching it. On one stage along the motor road, north-west of Ardakan, we had our highest camp at 9500 feet upon a desolate valley floor between two high ranges, the one on the right being the continuation of that behind Ardakan, and the one on the left a range which plunges and dies out at Ardakan village. The latter range, early in May, was attractively striped by the relics of the winter's snow, but all had been melted off the southern face of the mountains already. From this col we again caught a glimpse of the great Dina range, which became more and more imposing as we moved north-westwards across a plain and another col to the Kakan plain. All this country drains into the Rud Kur, one of the rivers flowing into an internal basin without an outlet to the sea. Kakan plain is dotted with small forts and villages. It was held by the Qashqai Turks, and was the last of their lands in this direction, beyond which over a col leading to Tul-i-Khushravi all the country lay in Boir Ahmadi hands. The two tribes were on bad terms and raids

were no uncommon experience. The old spheres of influence were well indicated by a guide we had from here, who for the first day was full of information and names about every hill and valley. The next day he clearly knew the ground, but names were rare; while on the following day his knowledge of the ground was incomplete and he was reduced to providing names for even the most prominent mountains out of his head.

From the Kakan plain we travelled northwards across a khaki-coloured ridge and camped on a terrace just above a salt-spring. An area of nearly 3 square miles is scrub covered, and on two sides of it are salt-springs, while volcanic rock in big blocks was found lying about on a pavement of silts unlike neighbouring ones. It is another of the salt-plugs which are so common near Bandar Abbas. Eastwards it overlooks a broad lowland of light-grey naked rocks stretching up to a dark even range beyond the Rud Kur. South-eastwards the Ardakan range rises up boldly and tails out into the ridge we have just crossed, whilst north-westwards Dina is hidden behind a group of irregular hills on the edge of which camp stands.

We moved northwards along the margin of these hills and crossed one large branch of the Rud Kur before rising to crest another high ridge, from which we descended to a group of three large villages, Diz-i-Kurd standing at the foot of a precipitous dark range amongst groups of poplar and willow trees. Fine crags form much of the southern face of the range, the top of which is nearly flat. It provides another excellent view-point for grasping the extent of Kuh-i-Dina, and is itself one of a group of mountains running in a line which converges with this range. The watershed between the Kur and the Karun, or the Khirsin tributary of the Karun, is situated below, and our next camp was under the Pass of the Lion, on which the mule track crosses the range, while the youthful Khirsin river cuts it in a precipitous gorge. From here we could see a col on the south-east end of Kuh-i-Dina which looked as if mules could cross it, but as no one who knew the route could be found, two of our own men went off to investigate. After three days they returned with the news that it was negotiable and by this route the caravan passed over, at 10,500 feet. It is called the Pass of the Barber, but we could discover no story to account for the name. The range 12,000 feet high on the south of this pass stands just in front of the Dina line, the bold escarpment of which makes a fine display. Above our camp at the foot of this, throughout the evening, rock falls were taking place at intervals of only a few minutes. The fallen material came rattling down two gullies in front of which were large light-grey talus cones, while as each fall occurred and the blocks came bounding down, clouds of dust rose which floated up above the 14,000-foot crest of the mountain. About ten days later when on the north-eastern side, I observed on a cloudless day spasmodic plumes of dust floating up above this point. Such continuous rapid crumbling of a mountain face is surely a rare phenomenon.

Three days of rough going, during which two more cols were crossed under the high cliffs of Dina, brought us to the plain of Sisakht. This is built up of gravel and soil as a terrace where the range in front of Dina plunges to the north-west. A few small villages hug the edge of the plain, much of which is irrigated and cultivated. It is shut in on the south by a chain of relatively

low hills from which can be seen the plain below at Tul-i-Khushravi and the river which leaves the plain and follows the fan-built plateau which we had crossed in the autumn.

Sisakht to Simarun

Before continuing our journey we made circuits from Sisakht farther north-west to join up with mapping previously done. In the course of this work we climbed the peak just above Sisakht about 3 miles south-west of the top of Kuh-i-Dina, when we were rewarded by an uninterrupted view along the range in both directions. Then we crossed the Bijan pass over which Sisakht stands guard. It is the only route across the Dina range throughout its length of 40 miles. Here we found others on the move, which during most of our journeying was not the case. After a steep climb to the pass an easy passage over scree and snow led us to the valley on the north-eastern side of Dina. In this valley minor ranges appear, but are small affairs compared with the slab-dressed slopes of Dina or with the dark range on the north-east. About 1933 an earthquake shook down a small village and caused a landslide. This landslide has followed the small valley below, down which it is now distributed as a tongue-shaped light-grey body of broken rock, looking in some lights from a little distance like a glacier. It is one and a half miles long, and up to a quarter of a mile broad. The one striking irregularity of the north-eastern slopes of Kuh-i-Dina is the big protuberance known as Kuh-i-Zarin. In the angle between this and the main range on the east stands a little town, Khafr, in which in spite of its distance from the Tigris several people live who travelled to Basrah or Baghdad in days gone by to work for a time as porters. Its stream, which is fordable in the morning, is filled in the afternoon with melting snow-water, making the primitive bridges essential.

A day later, having crossed the nose of Kuh-i-Zarin, we camped beside the ford across the Khirsin river, just above its entrance to the gorge across Dina. We forded it the next morning when the snow-water was at its lowest, but at the end of May it was still so deep as to be only just practicable with laden mules if the loads were not to be drenched. After a hot march to a spring near the crest of the north-eastern range, we looked over to the Simarun plain once more, which in another march we crossed, meeting on our way flocks, herds and camels of the Qashqai Turks who were moving up to their summer quarters beyond Simarun. Another stage brought us to the flanks of the range a few miles north of Simarun, a point which motor transport could easily reach and there, on June 13, the survey came to an end and the caravan was disbanded.

VARIATIONS IN BEHAVIOUR OF THE PERU COASTAL CURRENT—WITH AN HISTORICAL INTRODUCTION: *A paper read at the Afternoon Meeting of the Society on 9 March 1936, by*

E. R. GUNTHER

THE Royal Research Ship *William Scoresby* visited the west coast of South America in 1931 to carry out oceanographical investigations in the Peru Current. A survey of this region has long been required (Murray, 1895, II, App., p. vii, and Schott, 1931, p. 162); for although much has been written about it, few observations of a scientific nature have been made.

The main subject-matter of this paper is grouped under three heads. First, a generalized picture of the Peru Current is drawn, as it is known from the work of earlier observers and from the work of the Discovery Investigations; secondly, a number of recorded variations in the behaviour of the current are pointed out, which hitherto have eluded satisfactory explanation; and lastly, these records are considered in the light of results obtained on the present survey.

Historical

The history of the Peru Current begins in 1515 when Vasco Nuñez de Balboa first sighted the South Sea. It is thus recent in comparison with that of the western sea-board of the Indo-Pacific which dates back to antiquity. In the following account, the period is divided into four eras.

1500–1600	Era of Spanish Conquest.
1600–1800	Era of early British Voyagers.
1800–1875	Era of French Expeditions.
1875–1931	Era of German Oceanographers.

The first comprises the work of the early Spanish colonists. Their activities were concerned mainly with the northern part of the region, for though the southern route was laid open in 1519 when Magellan sailed through the Straits, it seems to have been little used until the arrival of the English voyagers, Magellan himself taking a route westwards across the open ocean. The second era is mostly made up of contributions from the English voyagers, the works of Frezier and Ulloa being noteworthy among those of other nationals. The third era from 1800–1875 may be identified with the advance of natural philosophy, and the last from 1875 to the present day with modern scientific progress. In the former Humboldt and the French expeditions take a leading part; Humboldt though a German may be classed with the French school since he travelled with Bonpland and his works were first published in French. Since 1850 there has been a spate of contributions from Chilean and Peruvian writers of which the interest lies mainly in local colour, but their calibre is not to be compared with the work of their Spanish forbears, nor with the work of the German school which is the most outstanding of the last era. By paying less attention to original observation, by making unwarranted assumptions, and by passing on earlier works re-hashed, latter-day writers have brought confusion to the subject, and it is with the object of winnowing out the authentic that the following historical notes have been compiled.

1500–1600 *Era of Spanish Conquest.*—Knowledge of strong current on the west coast of South America dates from the discovery in 1522 of the territory of Birú which is to-day part of Colombia and from which the modern state of Peru has derived its name. P. de Andagoya, at that time acting governor of the isthmus of Darien, who led this expedition, recorded the fact that:

> There are many currents in the South Sea, for which it can only be navigated close in-shore, except with long delay.

That a record should have been made within seven years of the sighting of the South Sea is remarkable. Fuller descriptions of the current and coastal climate came with the conquest of Peru. Augustine de Zarate, who was sent to Peru by the King of Spain within eleven years of Pizarro's conquest, gives the following account:

> It may appear difficult to some of my readers to comprehend why no rain should fall in the plain of Peru, . . . Those who have carefully considered this singular phenomenon, allege that it is occasioned by the continual prevalence of a strong south-west wind all along the coast and over the whole plain of Peru, which carries off all the vapours which rise from the sea and the land, without allowing them to rise sufficiently high in the air to gather and fall down again in rain. From the tops of the high mountains, these vapours are often seen far beneath on the plain in thick clouds, while all is quite clear and serene on the mountain. By the perpetual blowing of the same wind, the waters of the South-sea have a constant current along the coast to the northward. Others allege a different reason for this current; saying that the water of the South-sea having only a narrow outlet at the Straits of Magellan, which are only two leagues broad, and being there opposed by the Atlantic Ocean, they are forced to return to the northward along the coast of Chili and Peru. This constant wind and current render the navigation exceedingly difficult, from Panama to Peru for the greater part of the year; so that vessels are obliged always to tack to windward against wind and current.
>
> The whole coast of Peru abounds in fish of various kinds, among which are great quantities of sea-calves or seals, of several species. Beyond the river of Tumbez there are no caymans or alligators, which is supposed to be owing to the too great coolness of the sea and rivers, as these animals delight in heat; but it is more probable that their absence from the rivers of Peru is occasioned by their great rapidity as they usually frequent rivers that are very still.

Cieza de Leon (1553) and Acosta (1608) also describe conditions on the west coast, and refer to the effects of counter-current. The chronicler Pedro de Cieza de Leon compiled a list of sailing directions in which he says (p. 19):

> The time for navigating is during the months of January, February, and March, because in this season there are always fresh breezes from the north, and the vessels make short passages; while during the rest of the year the south wind prevails along the coast of Peru.

To this the Jesuit Father Joseph de Acosta added that the northerly winds are troublesome and unwholesome. As these are attributes of *El Niño*, they may be taken as the earliest records of that counter-current. Acosta further ascribes the dry climate of Peru to the fact that atmospheric moisture was insufficient to engender rain, which so far as it goes is in agreement with the

modern view. The low temperature of the coastal climate he assigns to various causes, one of which is the ocean near by, and the wind direction. He tells us (p. 95):

> . . . they put the water or wine which they drinke, into the Sea in flaggons to be refreshed, whereby wee may undoubtedly finde, that the ocean hath this propertie, to temper and moderate the excessive heat.

1600–1800 *Era of Early British Voyagers.*—The insight shown by these early Spanish colonists stands out when their writings are compared with later accounts. Scholarly knowledge of the current and of the coast came to a halt on the arrival of the early English voyagers. The buccaneers were presumably too concerned with the safety of their ship and with prospective hauls to record observations; and their piratic activities would reflect on those of the inhabitants of the coast. Fletcher (1628) throws a sidelight on Drake's visit to Callao:

> . . . for the masters and merchants were here most secure, having never been assaulted by enemies, and at this time feared the approach of none such as we were.

Likewise Funnel (1729, p. 18[1]), who took considerable interest in natural history, breaks off abruptly from a description of discoloured water, thus:

> . . . we were suddenly suprized with the change of the Colour of the water, which looked as red as Blood to as great a distance as we could see, which might be about 7 or 8 Leagues. At first we were mightily suprized; but recollecting ourselves, we sounded, but had no Ground at 170 Fathom. We then drew some Water up in Buckets, and poured some into a Glass. It still continued to look very red, till about a quarter of an Hour after it had been in the glass when all the red substance floated at top, and the water underneath was as clear as usual. . . . off Lima, the Capital City of the two great Empires of Peru and Chili . . . we furled all our sails to our Main-Sail, because we would not be seen by the Spaniards; and laid our Ship by, intending to watch all ships going in or out. At 5 in the Morning we made Sail again, and before we were aware, had like to have been upon the Rocks of Ormigas. . . . Having narrowly escaped these Rocks, we stood away to the Northward, and soon descried two Sail. We presently made a clear Ship, and gave chase, . . .

It was quite a sign of the times that Frezier (1716, preface) should be sent out to the west coast by Louis XIV, who "having been at vast Expence to support his Grandson upon the Thrown of *Spain*, thought this a proper Opportunity of getting a full Information of the least known Parts of the *Spanish West-Indies*, before the French, as well as the other Nations, should be excluded those seas by a Peace."

Again that Ulloa (Juan, 1748, pp. 197–203), who had been sent to South America to make physical and astronomical observations, was unable to complete them:

> We had now been three months at Quito, waiting till Mr. Hugot, instrument-maker to the Company, had finished . . . some repairs . . . But on the 5th of December, 1741, when we were animated with the hopes of concluding our task in two or three days, the melancholy news arrived at Quito, that

[1] In this edition page 18 is wrongly numbered as 11.

> Paita had been pillaged and burnt by a squadron of men of war, commanded by Commodore Anson; . . . As affairs of this nature admit of no delay, we immediately prepared for the journey, and leaving Quito the 16th of December, . . .

The hazards of life at sea when England was perennially at war with Spain must have effectively prevented collection and correlation of scientific data; and although Hook had designed oceanographical instruments in 1662, they seem not to have been used, in the southern hemisphere at any rate, before Cook's voyages. Richard Walter, writing on the west coast during Anson's voyage round the world in 1740, mentions especially his need of a thermometer; and, as will be seen later, it seems to have been left to Humboldt in 1802 to make the first temperature record. For two centuries, from 1600 to 1800, knowledge of the current was derived from passing references in the journals of old voyages; and of these, the observations of seafarers were the more valuable since they were less influenced by local tradition.

Thus Dampier (1705) makes the important observation that winds in the open ocean resemble the south-east trades more closely than winds near the Chilean coast which have a smaller easterly component. He also notes the similarity of conditions on the west coasts of South America and of South Africa. Whereas Betagh (1728, p. 267), who spent some years in Lima as a prisoner, is less accurate:

> One would expect it much hotter thereabouts than it is, there being no proportion between the heat of this climate in *America* and the same degree of latitude in *Africa;* for which there are two reasons: one is the cool temper of the air proceeding from the congealed snow on the mountains, which diffuses it self in every way: the other is, the humidity of the vapours which hang over the plains, and which are so frequent, that when I came first to Lima, I often expected it would rain.

Walter (1748, p. 251) compares the west coast of South America with the east, writing at length on questions of temperature:

> In our run along this coast we generally observed, that there was a current which *set us to the northward*, at the rate of ten or twelve miles each day. And now being in about eight degrees of South latitude, we began to be attended with vast numbers of *flying fish* and *bonitos*, which were the first we saw after our departure from the coast of Brazil. But it is remarkable, that on the East side of South America they extended to a much higher latitude than they do on the West side; . . . The reason for this diversity is doubtless the different *degrees of heat obtaining in the same latitude on different sides* of that Continent.

After a philosophic review of many other temperature anomalies he adopts the opinion earlier expressed by Betagh, that the cool water on the west coast is related to the height of the Andes: in the Gulf of Panama, where the Andes are relatively low, he points out that the water is warm, whereas off Peru where they are high, the water is cool. This and the formation of cloud has a refrigerating effect on the water. He ends his discourse with the hope that:

> as it is a subject in which mankind, especially travellers of all sorts, are very much interested, that it were more thoroughly and accurately examined, and that all ships bound to the warmer climates would furnish themselves with

thermometers of a known fabric, and would observe them daily, and register their observations; for considering the turn to philosophical subjects, which has obtained in Europe, for the last four score years, it is incredible how rarely any thing of this kind hath been attended to.

The accounts of Frezier and Ulloa reflect the influence of the traditions and myths that had become stock in trade on the mainland. Referring to Zarate's reason for the perpetual drought observed on the coast, Frezier (1716, p. 193) writes:

> Ce raisonnement n'a rien de vraisembable, car . . . à la Côte, . . . soufflent regulierement les vents de SO & de SSO, lesquels venant des climats froids du Pole Austral, rafraîchissent continuellement l'air, & le tiennent toujours à peu près au même degré de condensation.

Frezier was styled an experienced engineer and a mathematician qualified to make hydrographical observations for the use of mariners; and he supplemented the reason quoted above with the belief that the sea breeze is thickened by particles of salt and that this becomes better able to support clouds. Betagh, whose account was published after Frezier's, observes in this connection (1728, p. 268):

> Zarate the *Spanish* historian has given us the natural cause of this perpetual drought. . . . This is so fair and rational an account, that I wonder *Monsieur Frezier* has affected to contradict it. . . . Anyone who reads *Frezier's* voyage may see he has not only mistaken the *Spaniard*, but given us long conjectures of his own, very confused and improbable.

Ulloa, following a few years after Betagh, wrote of the low temperature (Juan, 1748, p. 65):

> The first cause of cold at Lima is the winds, which passing over the frozen climes of the south pole, bring hither part of the frigorific particles from those gelid regions.

After quoting Zarate and Frezier, or misquoting them as it seems, Ulloa advances an explanation of the dry climate which the present author has been unable to follow; and his translator adds yet another.

The interest in the climate shown by these writers was extended to the current; and the following reports indicate that its influence on local affairs was such that it had become a by-word. Betagh (pp. 242–243) describes an incident off Capo Blanco which led to his capture:

> We stood off and on the said cape seven or eight days expecting to meet with the Speedwell; and there we set ashore the *Spanish* captain, the *padre* and some gentlemen passengers. At last we espied a sail about five leagues distance, plying to windward: not doubting it was the *Speedwell* or *Success*, we stood towards her, while she kept edging towards us. About ten in the morning we were got near enough to discover it was a warlike ship, as she proved; tho' neither of those we wished for. . . . Hereupon Captain *Hatley* advising with me what to do, we . . . drest ourselves like *Spaniards*, and hoisted *Spanish* colours: we confined our prisoners in the great cabin, suffering none of them but the *Indians* and *Negros* to appear upon deck, that the pink might look as she did before; in which contrivance we had succeeded, but for the obstinacy of *John Sprake*, whom we could not keep off the deck.
>
> As the Admiral came up he fired a gun to leeward: hereupon we lowered our topsails, making easy sail till we got along side of him. Their first question

was, if we had heard any thing of the *English* privateer? we answered, No. The next was, how it happened we were got no farther on our way to Lima? We answered, by reason of the currents. They asked us two or three more questions, which we still answered in *Spanish*. They seemed thoroughly satisfyd; and were just getting their tacks aboard in order to leave us, when the said *Sprake* and two more of our men appeared on the main deck: a *Frenchman* aboard the admiral looking out at the mast-head spyd their long trowsers, by which knowing them to be *English* he cryd out, par *Dieu Monsieur, ils sont Anglois*.

Frezier, describing the passage from Callao to Valparaiso writes (Translation, 1717, p. 276):

The Regularity of the Winds at E.S.E. and S.E. and the Breezes at S.W. along the coast of *Peru*, made the Navigations so tedious, before the Method was found of running out to Sea, that Ships were six or seven Months of sailing from *Lima* to *La Conception*, because they only advanced by the Help of some small Northern Blasts and the Land-Breezes, during the night, and some Part of the morning. This shows, that the Want of understanding Natural Philosophy among Sailors, is a greater Evil than is imagined.

Ulloa, referring again to the current off northern Peru states (Juan, 1748, p. 194):

At all times this voyage is of a most disagreable and fatiguing length; . . . They relate here a story to this purpose, that the master of a merchant ship, who had been lately married at Paita, took his wife on board with him, in order to carry her to Callao. In the vessel she was delivered of a son, and before the ship reached Callao, the boy could read distinctly.

1800–1875 *Era of French Expeditions*.—Humboldt reached Truxillo in August 1802 after a voyage across the Andes and was with little doubt the first to dip a thermometer in the Coastal Current, and to make strictly scientific observations on the west coast. These observations were however a minor incident in his travels and references to them are few and widely scattered among his voluminous and generally discursive reports. Earlier writers, with the exception of Acosta, had maintained that the temperature of the water was lowered by that of the air. For the source of this cold Frezier and Ulloa had looked to the polar regions, Betagh and Walter to the high mountains. Humboldt's observations showed at once that the water was cooler than the air and could therefore not be cooled by it (Humboldt, 1810, p. 317). He also showed that the surface temperature rose with increasing distance from land, which, correlated with the known facts of in-shore current, formed the grounds for his conclusion that this represented a flow of cold water from high latitudes (Humboldt 1811, Translation, p. 149).

Now the heat of the sea not only varies according to the latitude but also according to the number of shallows, and the rapidity of the currents which flow from the different climates. On the coast of Peru, under the 8° and 12° of south latitude, I found the temperature of the South Sea at its surface, from 15° to 16° centigrades, while out of the current which sets in strongly from the straits of Magellan towards Cape Parina, the great equinoctial ocean is at a temperature of from 25° to 26°. Thus the thermometer fell at Lima in the months of July and August, 1801, to 13·5° and oranges will hardly grow there.

The conclusion was however inconsistent with the fact that off southern Patagonia surface current towards the north is negligible or absent, and this crucial fact threatened to cut right across Humboldt's theory. The objection is overcome in his manuscript, though perhaps not without misgiving, by supposing that in this region the current flows northward at an intermediate depth. Johnstone (1848) translates the version given by Berghaus as follows:

> Is the origin of the cold current to be sought for near the outlet of Magalhaen Strait, at Cape Pillar, where in November the temperature of the sea scarcely amounts to 41° or 42° ? [1] An intelligent Spanish seaman, Don Joseph de Moraleda, who commanded the ship in which I made the voyage from Callao to Guayaquil, assured me that, in the Archipelago of the Islands of Chonos and Huaytecas, the coasts of which he had explored, he had found the movement of the water which flows along the coast towards the north to be very slow. On the surface, it only moved at the rate of from three to five-tenths of a mile per hour, as a drift current; but careful observations with the lead had shown, that at a depth of from twelve to fifteen fathoms, the current in the same direction is much stronger. The agitated parts of the water, flowing between warmer layers, long maintain the low temperature of higher latitudes, and remain at a depth corresponding to their specific gravity.

Humboldt's views were taken for granted by the majority of nineteenth-century writers and were maintained by him in his Kosmos (1845), though by then they had been shown untenable. Bougainville (1837, p. 558) may be cited as one of the earliest to level criticism:

> M. de Humboldt parle d'un courant froid qui se porte avec impétuosité vers le Nord, depuis le détroit de Magellan jusqu'au cap de Parina, et dans lequel la température de l'Océan sur la côte de Lima, n'est que de 12·5° (th. R.); tandis que sous le même parallèle, mais en dehors du courant, elle est de 21°.—Ainsi qu'on vient de le voir, nous avons reconnu l'existence du courant portant au Nord; mais nos observations thermométriques ne donnent pas pour la côte du Chili, à l'attérage de Valparaiso, ce refroidissement si considérable de la température des eaux de la mer soumises à l'influence de ce courant.

Shortly afterwards, de Tessan (1844, p. 443), confronted with the same problem, suggested upwelling of the lower layers as the explanation of the low temperature.

> On doit, ce me semble, conclure de ce rapprochement que, dans le courant péruvien, l'eau de la surface est constamment renouvelée le long de la côte et remplacée par de l'eau provenant des couches plus basses et par conséquent plus froides; conséquence à laquelle nous étions déjà arrivés par des considérations purement mécaniques, qui reçoivent ainsi une sorte de confirmation du rapprochement précédent.

It is of historical interest that Humboldt had already conceived the idea of upwelling: not so much on the west coast where he suggested submarine volcanic action, as in explanation of patches of cool water over certain shoals and sandbanks in the Atlantic. Northerly current however he held to be the principal cause of the low temperatures, and later, no doubt influenced by

[1] 5° bis 6° (Berghaus, 1837, p. 581).

Duperrey's observations, the theory was made to embrace a current of Antarctic origin.

De Tessan's suggestion was ignored for many years, but when adopted the question arose as to how the upwelling was caused. In this connection the year 1844 has special interest, for contemporary with de Tessan, Maury in America had applied Hadley's Law of Deviation to ocean currents. Ferrel, (1860) who re-stated this law, considered that Humboldt's Current flowed northwards along the coast to fill the vacuum that would otherwise have been caused by the withdrawal of surface water, and especially the South Equatorial Current from the west coast. The possibility of this vacuum being filled by vertical currents does not seem to have occurred to him, but was suggested by Dinklage in 1874.

1875–1931 *Era of German Oceanographers.*—Dinklage, captain of the barque *Charlotte*, found off Callao no evidence of current close to the shore where the water was coldest but he experienced westerly set out to sea. Westerly set had by then become a generally accepted fact of surface drift on the west coast (Garcia, 1863). The cause of upwelling was attributed by him to this westerly set and to the effect of trade winds over the ocean at large; the possible effect of the Earth's rotation not being considered (Schott, 1891, p. 215).

> Durch die grosse Verdunstung in dem hier jedenfalls sehr dürren Passat und besonders in den wärmern westlichern Regionen desselben, wird das Wasser von der wallgleichen Südnordküste fortwährend abgesogen und durch den Wind westwärts abgetrieben, da unter Land bei dem kältern Klima und den häufig vom wärmern Wasser herwehenden, nebligen Winden die Verdunstung nur gering sein kann. *Diese westliche Oberflächendrift zu ersetzen, muss unter das Wasser dem Lande zusetzen, und wird dann dicht unter der Küste sozusagen—aufquellen.*

The idea underlying this thesis formed the basis of Buchan's view in 1895 (p. 20).

> It is probable that the great volume of, and distance travelled by, these currents in the broad Pacific as compared with other oceans directly results in a stronger and more widespread upwelling, accompanied with a correspondingly extensive diminution of temperature.

The link between the theory of upwelling and the Law of Deviation was added by Witte (1880), who showed that the cool water fringing certain meridianal coasts might be explained in terms of upwelling if the surface layers of the ocean were to diverge from the coast as a result of the Earth's rotation, or of off-shore wind. The specific application of this theory to conditions on the west coast was made by Hollmann in 1882. To this theory Nansen (1902) and Ekman (1905) added the corollary that a wind-induced current at the absolute surface tends to deflect 45° to the left (southern hemisphere) of the wind direction, while the surface stratum tends to deflect at right angles. The special conditions arising near a coast-line are considered by the latter author who has placed the theories on a mathematical basis.

The progress that was being made by these and other nineteenth-century investigators was however very largely off-set in print by the majority of writers who either took Humboldt's theory for granted, misrepresented it,

or expressed views which meet with as little general acceptance. Buchanan (1886) went to the extreme of denying the existence of northerly current, and of attributing the upwelling solely to the action of off-shore wind. This view, based on the theory of trade belts, has been followed by Mill (1899), Zorell (1925), Semple (1931), and many others, but is easily disproved because coastal winds tend to blow parallel to the coast and not off shore. The theory of trade belts has long given place to the theory of high-pressure centres.

Coker (1918) supposes that the cause of the upwelling may be found in the momentum or centrifugal force of the current, bearing against a westward-tending coast; while Murphy (1925) suggests that the submarine slope of the continent shoulders off to seaward the warmer and lighter surface layers of a deep impinging stream. Sverdrup (1931) suggests that upwelling within the surface current may be found when it approaches the coast. Each of these theories is incompatible with the view that the Peru Current is essentially a current which diverges from the coast (Schott, 1931). The truth of this view was demonstrated repeatedly during the work of the *William Scoresby*, which showed that when the surface current converges with the coast, the upwelling is checked and the cool water may even subside.

The depth from which water wells up has likewise given rise to diversity of opinion. Reclus (1877), following de Tessan (1844) and Arago (1840), placed the depth of the current at more than 1000 metres: the two latter maintained that the current must be very deep else its density would cause it to sink and a minimum figure of 1790 m. is given. Coker (1918), Brooks (1929), and Murphy (1925) consider that polar-fed bottom water wells up and a diagram published by the latter leaves no doubt of his meaning. Upwelling from a depth of no more than 300 metres is suggested by Sverdrup (1931) on the basis of the *Carnegie's* observations, and with this the *William Scoresby's* results are in fair agreement.

Works in which Humboldt's classic theory of a current of Antarctic origin is adopted are innumerable,[1] but Thoulet (1928) alone traces the low temperature and low salinity of the current to the melting of snow on the Cordillera. The fact that upwelling water, and therefore the coastal current, is more saline than the open ocean south of the sub-tropical convergence, the region where precipitation is greatest and rivers may be torrential, makes Thoulet's theory inadmissible on any but the most modest scale.

Coker (1918) and Stiglich (1925), in estimating the causes of temperature variations within the current, allow for the influence of icebergs in southern seas. Another cause pointed out by Coker, Somerville (1923), and Murphy (1925), is a swinging of the cold current toward or away from the coast. This idea is apparently taken from the local fishermen and will be dealt with later. In this connection Zorell (1928) also states that the Humboldt Current is deflected from the coast by the southerly flow of *El Niño*. A suggestion has

[1] The following may be cited: Duperrey (1829), Berghaus (1837), Arago (1840), Johnstone (1848), Findlay (1853), Kerhallet (1856), Wüllerstorf-Urbair (1862), Bent (1869), Reclus (1877), Wolf (1879), Carranza (1891), Carrillo (1892), Raimondi (1897), Smith (1899), Melo (1905), Mossman (1909), Bowman (1916), Coker (1918), Stiglich (1925), Thoulet (1928), Sheppard (1931).

also been made that the *Niño* counter-current may be met with out to sea; but the writer has been unable to trace the passage alluded to by Schott (1931, p. 210):

> . . . da schon Murphy festgestellt hat, dass warmes *niño*-Wasser einige Sm ab Land vorhanden sein kann, während gleichzeitig dicht unter Land noch kaltes Wasser sich hält.

That Humboldt was the first to discern the current and to discover its low temperature is gravely stated by Findlay (1853), Laughton (1873), and others; and to give further examples of sketchy methods in the treatment of this subject, we find *El Niño* has been ascribed to such varied causes as the flooding of the Guayaquil river (Carranza, 1891, Melo, 1906, Stiglich, 1918) and excessive evaporation in higher latitudes during the summer solstice (Raimondi, 1897): that statements to the effect that polar-fed bottom water wells up, and that the upwelling is caused by impingement of the current against the bottom contour, and that the current is a surface flow of Antarctic origin, have been published so recently as 1925 and 1931.

Writers of the present century inherited these traditions and usually passed them on; few therefore are authorities. We would except Hoffmann (1884) and Krümmel (1911). Since 1930 however renewed interest in the current has been shown and the work of Valleau, Sverdrup, Schweigger, Torrico, and particularly Schott, has thrown new light on the subject. Valleau (1930) and Schott (1931, 1932, and 1935) have examined the evidence critically. Schott's work, the first two parts of which were published in Germany in May 1931, the very month in which the *William Scoresby* began her investigations, is the most complete account of the hydrology of the region that has yet appeared. Sverdrup (1931) and Schweigger (1931) publish original observations collected respectively in the open ocean and close to the coast, the first attempts made to collect sub-surface hydrological data with modern instruments.[1] The work of the *Carnegie* extended far into the ocean and traversed the eastern South Pacific in several directions. Her observations are to some extent complementary to the work of the *William Scoresby* and are therefore of particular value to us.

Nomenclature.—Writers up to 1857, including Humboldt himself, give no specific name to the currents on the west coast. Berghaus (1837, p. 572) refers to it therefore as "Der Strom kalten Wassers längs der West küste von Südamerica, geschildert von A. von Humboldt." On p. 582 this he contracts to "peruanische kalte Küstenströmung"; and on p. 584 to "peruanische Strömung," but he also adds the following footnote:

> Weshalb man sie auch Recht "Humboldt's Strömung" nennen kann, wie es an westlichen Eingang des Englischen Kanals einen "Rennels-Current" giebt, dessen Existenz zuerst von Rennel nachgewiesen wurde.

In his Physikal Atlas of 1837, published 1839, Berghaus adheres to "Peruanisch. Küstenstrom kalten Wassers" and to the westwards of it differentiate

[1] Exploratory observations beneath the surface in the eastern South Pacific have been made by the *Blossom* (1825–28), *La Bonite* (1836), *La Vénus* (1837–38), the *Herald* (1845), and the *Challenger* (1875).

another current flowing partly towards the east, which is therefore oceanic and warm, by the name of "Mentor's Gegen Drift."

De Tessan upholds the name "le courant péruvien" in 1844, and Johnstone (1848) follows Berghaus with the names "Peruvian Coast Current of Cold Water," adding also "Humboldt's or Peruvian Current": in 1850, more logically, he adds "Chili-Peruanic Current." Herschel (1849, p. 59) gives "Peruvian Current." Thus to the end of the first half of the nineteenth century two currents were recognized: a coastal and an oceanic; and authors expressed a preference for the geographical form of nomenclature.

In the second half of the nineteenth century the name "Humboldt's Current" came to take the place of Peruvian Current, doubtless owing to the veneration in which Humboldt's name was beginning to be held. Thus Herschel, who used "Peruvian Current" in 1849, used "Humboldt's Current" in 1867 (p. 233): and Maury (1855) wrote "The Humboldt Current of Peru, which the great and good man whose name it bears was the first to discover."

Kerhallet (1856) followed Berghaus and Johnstone in making the distinction of the in-shore and off-shore currents, but interprets the "Mentor Current" differently, regarding it as having only northerly flow; Loughton (1870) suggested that the "Mentor Current" and the "Peruvian Cold Current or Humboldt's Current" were indistinguishable and that in consequence retention of the name "Mentor Current" was not justified. This view implied enormous breadth in the Humboldt or Peru Current and that it was no longer to be regarded as merely a coastal current. Tizard, Moseley, Buchanan, and Murray (1885), who as authors of the *Challenger* Narrative might be taken as representing the Expedition's view, refer to it as the Peruvian Current in Part I (p. 363), but as the Humboldt Current in Part II (p. 990). In the latter they recognize its existence as far out as Juan Fernandez. Sverdrup (1931) also recognizes enormous breadth, calling it the Peruvian Current. Other writers however refer the names Humboldt Current and Peru Current to a relatively narrow zone. Schott (1931) recommends that the name Humboldt Current should be dropped in favour of Peru Current on the grounds that currents are usually called after the coasts along which they flow, but makes no suggestion as to its breadth.

Wüst (1935) takes the opposite view; but in giving Krümmel the credit for the name Peru Current is unfair to the earlier German work of Dinklage (Schott, 1891, p. 215), Hoffmann (1884), and Wolf (1879). In its lack of impartiality it is doubtful whether Wüst's paper does justice to the subject or to Berghaus, whom he misquotes on some twenty-two occasions. By further and more extensive misquoting, Wüst shifts the emphasis in Sverdrup's (1931) paper from the depth affected by upwelling to the northerly transport of cold water along the coasts of Chile and Peru; and the implication that this was Humboldt's thesis is put forward as a reason for retaining the latter's name. The stress laid on a change over in the name from "Peru Strmg." to "Humboldt Str." in the 1931 edition of Sydow-Wagners Methodischer Schul-Atlas—in other respects lacking accuracy in its treatment of the current—like other suggestions Wüst has made, gives the article a political rather than a scientific complexion.

Investigation of conditions at and below the surface in the coastal region

during the present survey has shown that the current close in shore, which we shall look upon as the Peru Coastal Current, has an individuality of its own and has little in common with the adjacent open ocean which may be referred to as the Peru Oceanic Current. Not only has the Peru Coastal Current a greater velocity, but as seafarers know, its direction has a marked component towards the north, whereas the Peru Oceanic Current sets more towards the west. Surface layers in the Oceanic Current are impoverished since they are cut off from supplies of nutrient salts in the lower layers by a well-marked discontinuity layer; near the coast on the other hand, as will be shown later, vertical currents replenish the surface layers and lead to the production of rich phytoplankton, zooplankton, and animals of economic importance. Incidentally the cool water nearest the coast in the Peru Coastal Current contributes to the formation of cloud over the Chilean and Peruvian littoral; and to this cloud may be due the green of the waters closest in shore since diatoms in weak illumination collect near the surface whereas in sun-lit waters they sink deeper and display the phenomenon of systrophe.

In the short time allotted for the survey the *William Scoresby* was unable to make observations farther than 100 and 200 miles from land. Hydrological and biological conditions within this distance reflected the predominating influence of upwelled water. Thus surface isotherms ran in a direction more nearly parallel to the coast than parallel to latitude (Fig. 2), and the volumes of plankton catches over the whole of this zone were not very much less than those right in shore. In the winter months of 1931 therefore the influence of coastal phenomena extended over a wider area than is usually allowed for the Peru Current (Humboldt, 1826, Hollmann, 1882, Stiglich, 1918, Murphy, 1923, Torrico, 1933, etc.)

Although the Peru Coastal Current is thus shown to have a marked individuality, and in origin is fundamentally distinct from the more extensive Peru Oceanic Current, there is no sharp division between the two. Moreover, owing to the great variability of conditions on the west coast, and to the occurrence of counter-currents, any boundary between the two currents must be arbitrary. As water of the Peru Coastal Current drifts westwards it undergoes changes and mixes with the Oceanic Current. This may be seen in the different breadth of the several zones characterized respectively by strong northerly current, by nutrient salts in high concentration, by coloured water, by the dense bird and seal populations, by plankton, and by cool water.

The distribution of surface isotherms seems to be the most comprehensive of these characteristics, for whereas usually these run east and west parallel to latitude, where they come under the preponderating influence of the upwelled water, they change direction and, as already noted, run parallel to the coast. It is where they change direction, *i.e.* where they run from south-west to north-east, that the boundary between the two currents might arbitrarily be placed, and accordingly the Peru Coastal Current can be regarded as a relatively small part of the eastern limb of the anticyclonic circulation.

General Account of the Current.—Three of the processes suggested by earlier writers are probably at work in bringing about divergence of surface water

from the coast, and its corollary, upwelling. In their order of probable importance they are :

I. Aspiration westwards by oceanic drift.
II. Influence of Earth's rotation on northerly current.
III. Off-shore wind.

The effect upon water of wind at a distance which is far removed from the scene of investigation (Dinklage's view) is difficult to demonstrate, except perhaps by calculations of surface gradient. It may be significant however that on the present survey some appearance of upwelling was found on the west coast at every locality examined, and in meteorological and hydrological conditions which locally looked the reverse of favourable to it. The influence of the Earth's rotation on northerly current also appears to have been demonstrated among our results, but it is not easily proved, because upwelling being also caused by other means, the influence of the Earth's rotation is liable to be masked.

It is to Witte also that we owe the suggestion that upwelling should follow if the surface layers of the ocean were driven away from the coast by the action of off-shore wind. Such a wind was experienced only once during the present survey, and it came for rather less than eight hours between spells of southerly wind at Antofagasta. Off-shore wind cannot therefore be looked upon as widespread, and on this coast upwelling must usually be due to other causes.

The surface circulation on the west coast participates in the vast anti-cyclonic gyratory movement of the eastern South Pacific. The means to make accurate current measurements were not at our disposal, but we were able, sometimes, to register the drift of the ship in a direction parallel to the coast, and from this a broad conception of the nature of the surface flow may be obtained.

In Fig. 1 the ratio of northerly to southerly drift at different distances from the coast is plotted separately for Peru and Chile, and in combination for the west coast as a whole. The mean northerly drift is seen to be less than 15 miles a day, and as this includes windage, the strength of the current, at the most, probably averages less than 10 miles a day.

A counter-current close in shore has frequently been recorded on this coast, and is presumably of the type associated with coastal eddies. Observations at a distance from the coast, although few in number, give definite evidence of counter-current in the open sea off Peru.

Northerly drift is seen to be strongest in shore and to diminish with distance from land. Southerly winds, on the other hand, are stronger and more certain in the open sea. It is therefore probable that this decrease of northerly drift with distance from land is attended by an increasing set towards the west. The universality of upwelling off both Chile and Peru is indeed evidence that westerly set of the surface layers is in progress. This is shown by sections illustrating the distribution of the temperature and phosphate content of the current (Fig. 6).

The continual upwelling process close to the coast is the cause of the phenomenally rich marine life, because it brings to the well-illuminated layers the inexhaustible store of nutrient salts of the ocean depths, upon which the plant elements of the plankton depend for their growth and reproduction.

The thick growth of plant life which is sustained by this constant replenishment of the surface layers gives to the coastal water a greenish colour: in the open ocean, on the other hand, the water is blue or indigo. The phytoplankton

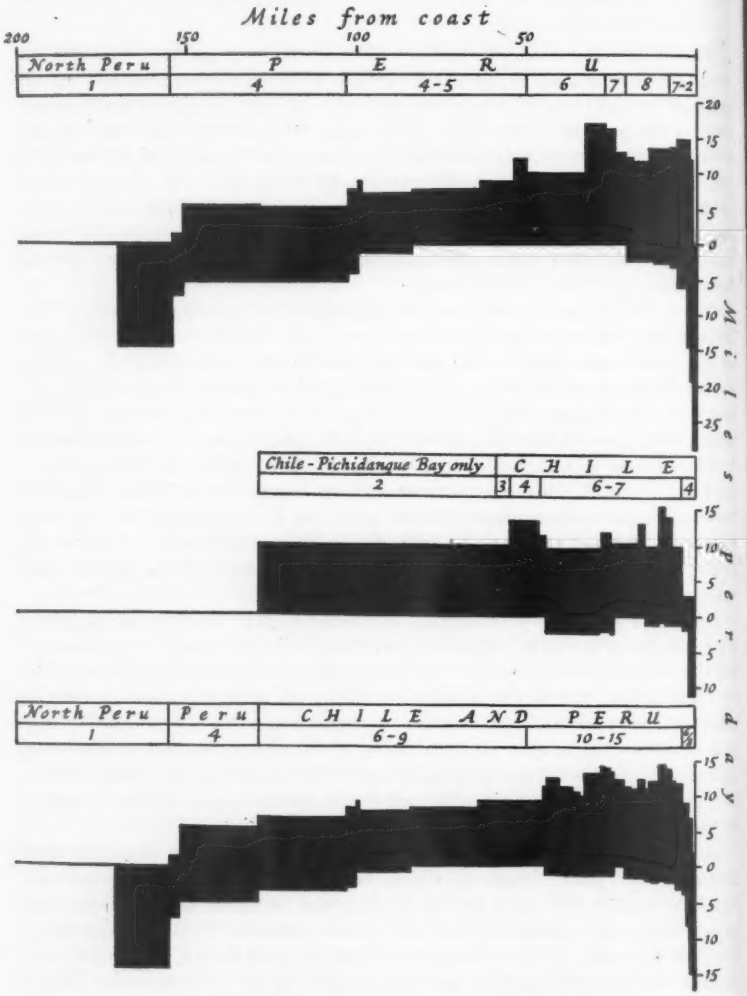


Fig. 1. Ratio of northerly to southerly drift

and the animal plankton that feeds upon it constitute the normal food chain of the animals of economic importance, or of potential economic importance; and of these whales, porpoises, seals, birds, fish, and squids might be mentioned. The birds are particularly striking as an example of the commercially

valuable animals, not only because of the value of their guano, but also because they are a very conspicuous feature of the landscape.

Before introducing the results of our own investigations a brief reference to the *Niño* current should be made. The phenomenon is known to local fishermen by this name, meaning "The Child," because it usually happens in the months following Christmas, which here coincides with the southern summer (Carillo, 1892, p. 83). At this season the North Atlantic trade winds enter the southern hemisphere and by reversing the physical conditions bring about a rainy season on a coast which is for the most part desert.

These northerly winds reverse the trend of surface currents and they drive hot, poorly saline water of the Equatorial Counter-Current southwards (Schott, 1931). This is the *Niño* current, and in abnormal years may carry high temperatures as far south as the 12th to 15th parallel. As it flows from north to south, it tends to converge with the coast and is therefore a coastal current. The sudden rise in temperature kills fish and plankton, which then decompose, discolouring the water and evolving quantities of sulphuretted hydrogen. These cataclysmic effects are variously referred to by the Peruvian name of *aguaje* and by the English name of "the Painter," and especially the "Callao Painter," because of the darkening effect the hydrogen sulphide has upon the ships there lying at anchor. Putrefying organisms are washed up on miles of beach and are so nauseating that the military are sometimes ordered out to bury them (Hutchinson, 1873, Raimondi, 1897, Stiglich, 1925).

More serious is the loss of food to the guano birds, which contract disease, die of starvation, or migrate wholesale southwards; and this being the nesting period, the young are left to perish in their nests (Sclater, 1913). The loss of this to the guano industry is estimated to run into thousands of pounds. Fortunately extremes in *El Niño* are of rare occurrence, and the hot water soon retreats with the reappearance of normal south-east trades, upwelling returns, and conditions in the sea once again become normal.

Recorded Variations of the Current

One of the characteristics most often repeated in descriptions of the Peru Current is its "weak and variable nature." Different writers give very different estimates of its velocity towards the north: Valleau (1930, p. 67) summarizes the position thus:

Krümmel notes (*Handbuch der Ozeanographie* II, 714–715) that, near the coast, the currents are not only very irregular, but also very weak and of no importance whatever to navigation; they are, likewise, very weak off shore. This is Buchanan's opinion also, and he goes so far as totally to deny their existence in coastal waters (J. Y. Buchanan, Accounts rendered of work done and things seen, p. 105, note). Yet, navigators concur in admitting the reality of a general movement, from S. to N., which is more noticeable near land than in the open, of a mean rate, between Valparaiso and Cobija, of 9·6 miles in 24 hours (Sailing Directions, No. 985). For the southern autumns, the Washington Pilot Charts give diurnal velocities of current varying between nil and 35 miles off Pisco. It may be taken for granted that on the whole the Humboldt Current represents a very irregular drift manifestly connected with the variations of the trade wind. Surface

temperature similarly is known to show a considerable range of variation, and according to Schott the quantity of upwelling also varies from place to place. In consequence of this, the surface temperature is depressed in complicated and irregular variations along the coast.

The disappearance of cool water from the coast is a phenomenon familiar to local fishermen, who explain it on the supposition that the cold current has swung away from the shore (Coker, 1918). According to Stiglich (1925, p. 212) fishermen sometimes find the water off shore off Mollendo so warm that they say it is like soup.

The *aguaje* phenomenon again, with the attendant discoloration of the water and the smell which it engenders, comes not only with *El Niño* but may occur at other times of the year with an irregularity hitherto unexplainable. Owing to its importance to the fisheries it has come to be the subject of fishermen's lore. By the fishermen *aguaje* is associated with warm water, its colour varying from green, yellow, red, and grey to black. According to the description given by Stiglich *aguaje* sometimes attains great intensity, and each time it reaches the beach it becomes redder, forming eddies by the shore. The fish, and above all corvina, collect in these eddies. When *aguaje* draws off the fish remain stupefied near the beach and with them all other fish with their food—shrimps, molluscs, sea urchins, cuttlefish, and other animals. Red *aguaje* may go away leaving the water frothy. They say that fish washed up on the beach are poisonous and produce a variety of complaints from headache, stomach-ache, dreams, and sea-sickness to feeble-mindedness. The appearance of *aguaje* is thought to be bound up with questions of current, but hitherto data have been insufficient to give any definite information.

Currents towards the south again are very variable in their occurrence. On this point the leading pilot books still quote FitzRoy (King and FitzRoy, 1850, pp. 388–389), who gave the following after his voyage in the *Beagle* a century ago: "The periods at which this southerly movement takes place cannot be foreseen with any degree of certainty. Neither the seasons, the age of the moon, nor any of those causes to which we so freely ascribe the currents off other coasts seem to have any influence here. . . . Again, no regularities or irregularities in the coast-line seem to have any effect on the main body of the current, and every fresh observation that has been made serves to awaken fresh curiosity without helping to elicit the source of these singular but interesting anomalies."

These examples will suffice to show that this current cannot be dismissed, as some authors are wont to do, with the words "Extraordinary uniformity is, after all, the outstanding oceanic feature of the Peruvian littoral" (Murphy, 1925). While our principal aim in this investigation has been to ascertain the working of the Peru Current under normal conditions—and there is nothing to suggest that conditions during the survey were not normal—our data include many observations of an apparently anomalous nature, data which in FitzRoy's words "serve to awaken fresh curiosity."

Results and their Interpretation

Let us first examine the distribution of surface temperature on the west coast, as we found it in 1931. Off Chile the isotherms are seen to run pretty

Distribution of surface isotherms (C°) off Chile (May to June) and off Peru (June to August.)
C. Blanco
P. Payta
P. Aguja
Puerto Chicama
Miles
50 0 200 400 600
Callao
Pisco
San Juan
Arica
Antofagasta
Caldera
Coquimbo
Pichidanque Bay
Valparaiso
C. Carranza
Corral
P E R U
C H I L E
N

Fig. 2

well parallel to the coast, converging with it slightly; but they indicate that upwelling was rather more vigorous at some points than at others. A record of rather warm water in the Bight of Arica seems indicative of a wedge of warm water lying off the Peruvian coast. Off Peru again it is evident that some

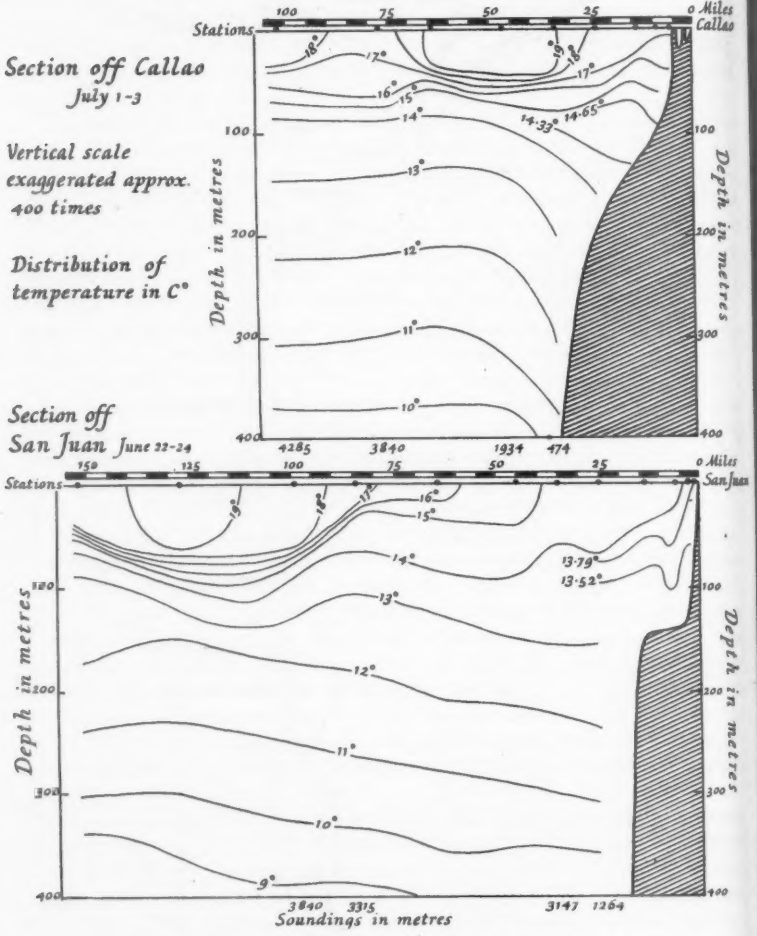

Section off Callao
July 1-3
Vertical scale exaggerated approx. 400 times
Distribution of temperature in C°
Stations
100 75 50 25 0 Miles Callao
Depth in metres
Depth in metres
4285 3840 1934 474
Section off San Juan June 22-24
150 125 100 75 50 25 0 Miles San Juan
Depth in metres
Depth in metres
3840 3315 3147 1264
Soundings in metres

Fig. 3. Distribution of temperature (C°)

localities show more active upwelling and others less. The presence of cooler water in the open ocean to the west of the warm wedge is shown at several localities.

A winding shape is given to the wedge as a result of contouring the isotherms of 18°, 19°, and 20° C. in the simplest manner possible; but it is hypothetical

to the extent that we have few data in regions far from the coast. For this reason some of the contours have been broken.

There are however objections to postulating continuity in a counter-current occupying this position. In the first place its structure in section off Callao and off San Juan is seen to be remarkably similar. This might at first seem to favour connecting them together; but the two localities are some 300 miles apart and it is unlikely that in travelling this distance the temperature, salinity, and general structure of the wedge could survive so little altered as shown in these sections.

Furthermore off Callao the ship's drift was almost negligible, whereas off San Juan the current in the wedge was sufficiently pronounced to carry her south-east against the wind. From a theoretical standpoint also if it experienced a flow southwards from Callao to San Juan, the wedge should tend to deflect to the left and to converge with the coast, and would not presumably swing to the right into the open ocean. Evidence from among our results is unfortunately insufficient to enable us to interpret this wedge differently, but a mass of very suggestive information has been accumulated by earlier observers which until now has been written off under the general heading of "weak and variable nature of the current."

It is traditional that northerly current is of most account off two particular regions: off the San Juan–Mollendo region and off the Eten–Sechura region (Somerville, 1923). Callao, on the other hand, has been noted as a locality where current is frequently either negligible or absent. The records of Buchanan and Dinklage might be cited, and our own experience was very similar.

Westerly set has usually attracted most attention off northern Peru, and again this was one of the few localities where it was sufficiently emphasized to be noted by us. One of the few entries which draw attention to westerly set in the South American Pilot states that off the Lobos Islands vessels have been set as much as 36 miles to westward of their course. Westerly set has also been mentioned, particularly off the Pisco region, by the American hydrographer Ray; but our ship, taking a route close in shore, had no chance of observing it.

The identification of areas where cool water at the surface was most prevalent during our survey with the regions of traditional current is no chance coincidence but a correlation to be expected. Moreover the accompaniment of westerly set is equally a corollary. Thus areas of strong current alternate with areas of negligible current, and corresponding with them, areas of active upwelling alternate with areas of reduced upwelling, each apparently falling within a system of its own. These correlations taken in conjunction with our own data make it possible to suggest that the warm water wedge represents, not one counter-current, but two counter-currents of compensation (Fig. 4). They look indeed as though they were each the oceanic limb of a vast anti-cyclonic eddy.

Passing now to the question whether counter-currents of this type are recurrent or permanent—that is, whether they are a normal feature of the circulation—observations made in 1927 and 1929 by the German ships *Emden* and *Nitocris* are suggestive. Schott (1931) has published a graph

illustrating the surface temperature along the course of the current (that is, parallel to the coast), from latitude 30° S. to north of the Equator. The temperature, instead of increasing regularly from south to north, displays a series of peaks and troughs which Schott has contrasted with the mean temperature at 100 miles off the shore. The recurring way in which upwelling sets in with a sudden fall of temperature and dies away northwards, so that finally almost normal values are found for short distances, has led Schott to distinguish four natural regions. A record made by the *Nitocris* is almost identical; but the value of these figures is somewhat lessened by the fact that they do not indicate the distances at which the ships were working off any

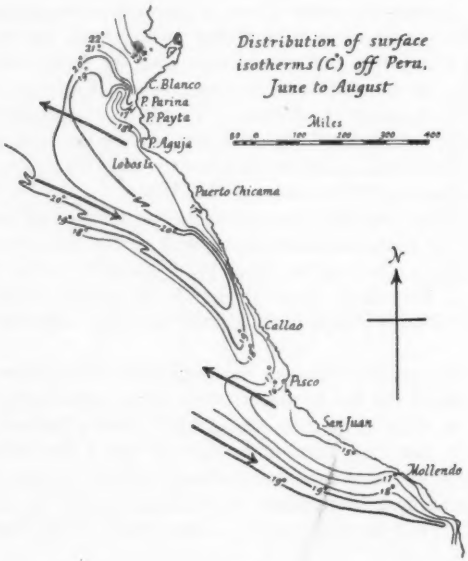


Fig. 4

given part of the coast. Nevertheless the same regions can be distinguished in curves drawn from our own data, curves which represent the temperature in zones at three different distances from the coast (Fig. 5). For the purposes of comparison, the limits of the regions recognized by Schott have been indicated below the regions as distinguished in our own curves: the agreement is seen to be remarkably close.

This argues a degree of permanence in these upwelling centres, at least during some seasons of the year, and their correspondence with the wedges makes it look as though the anticyclonic swirls might be a normal feature of the circulation. They have been indicated diagrammatically by arrows which point towards the curves in regions of convergence, but away from them in regions of divergence, that is, of westerly set. One would also expect to find analogous eddies, though perhaps less well developed, in conjunction

with the regions off the Chilean coast. Their hypothetical presence in these regions has been indicated, but more than that cannot be said.

Such a system of swirls and counter-currents might explain the records occasionally met with of southerly drift in the open ocean. Southerly drift was experienced by Frezier, Ulloa, Belcher, and Stiglich, and easterly drift in the region (18°–20° S. and 83°–85° W.) by the Prussian sloop *Mentor* in 1823. Mentor's Gegen Drift, as Berghaus (1839) called it on his chart of

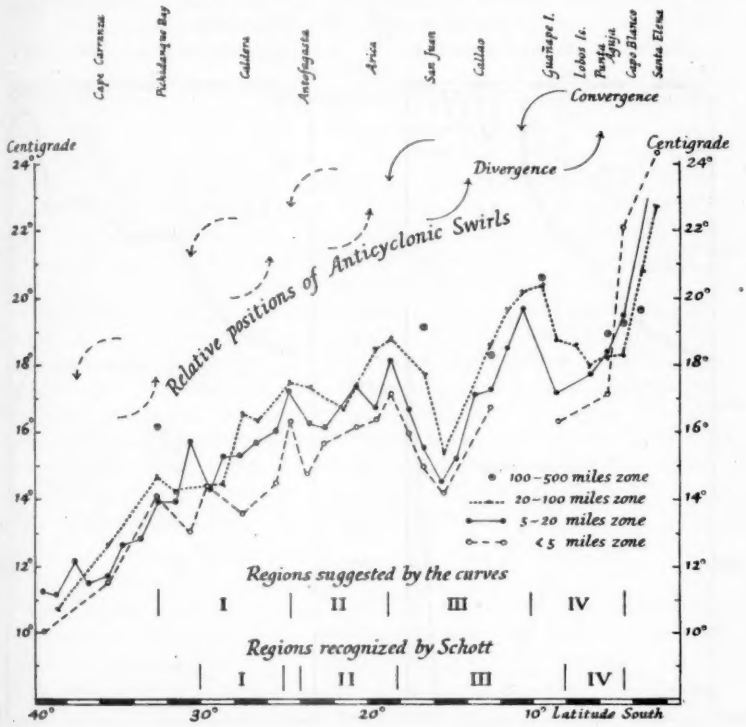


Fig. 5

1837, has been questioned by various authorities, but it seems plausible in the light of our results.

The possible relationship of these swirls to the appearance of *aguaje* may now be considered. In 1923 the guano birds fled from their nests and *aguaje* made its appearance, not only after Christmas, but from May to July also. The temperature observations published by Lavalle (1923) show that the temperature in 1923 was much higher than in the two preceding years; still further, they show that off the more southern of these islands (Palominos Island) the temperature was higher than off the Guañape Islands, some 250 miles to the northward. This rise in temperature is not likely to have

been produced, then, by a coastal current flowing from north to south, and is not likely therefore to have been due to a repetition out of season of the *Niño* current. On these grounds one may suggest that the counter-current was oceanic and was an over-developed wedge of the type met with during our survey. These anticyclonic swirls, in fact, may have as disturbing an effect upon the marine life as has the *Niño* phenomenon itself.

Considering this conclusion, the peculiar colours in the sea met by us off

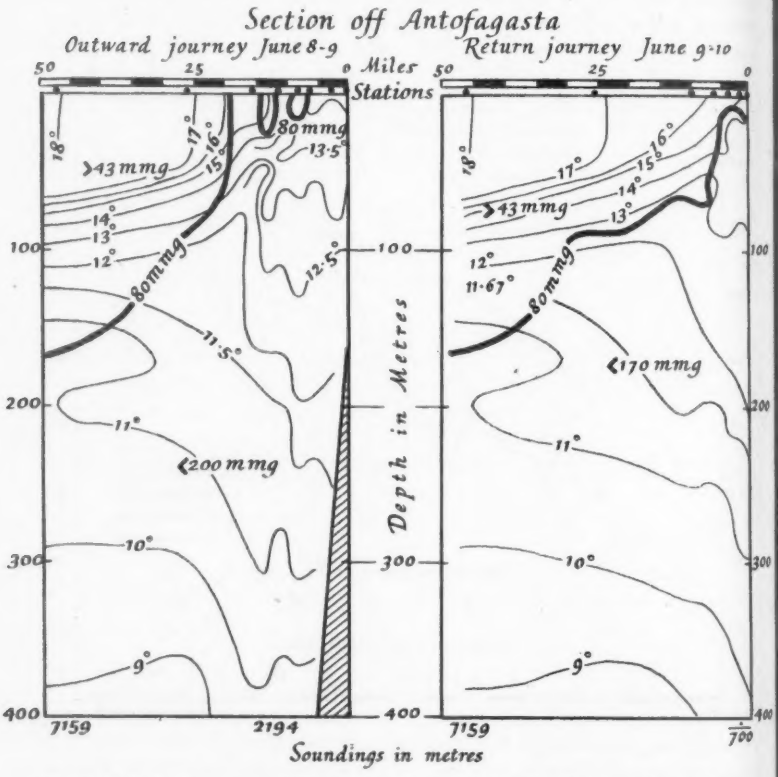


Fig. 6. Relation between wind and upwelling, showing distribution of temperature and (thick lines) phosphate.

central Peru deserve mention. The usual colour of the coastal water is green and of the open ocean blue and indigo. Off Pisco however the sea was coloured ochraceous-salmon, off Callao tawny olive and russet with patches of rusty brown foam, and off the Guañape Islands khaki (Gunther, 1936). While they might be capable of explanation in terms of normal animal plankton, this is unlikely. On the other hand, their occurring at contiguous localities and nowhere else on the west coast and their occurring where the warm wedge

was converging with the coast is suggestive that they might have been a form of *aguaje*. The rusty-coloured foam especially was reminiscent of Stiglich's remark that red *aguaje* may go away leaving the water frothy.

We have not as yet been able to form any definite views on the causes of these swirls. While the warm wedges appear to be currents of compensation, there must be other factors, possibly meteorological, which determine their position. A study of the relation between wind and water movement (Gunther, 1936) has given grounds for supposing that the strength of upwelling is increased by southerly and easterly wind and decreased by northerly and westerly (Fig. 6). Thus a change of wind from the former to the latter quarter has been followed within a space of a few hours by a rise of the surface temperature in shore. Among alternative theories put forward to account for these changes of temperature is subsidence of the cool heavier water. According to this view the welling or the sinking of in-shore water is, up to a point, balanced against the force and direction of local wind. As the process would be reversible, it may be described as a vertical swing; and in so far as its effect upon coastal temperature might resemble a disappearance of the cool water, the mechanism might underlie the fishermen's belief in a horizontal swinging of the cool current away from the shore.

Coastal counter-currents, of which Fig. 1 gives an indication, were usually found associated with centres of upwelling and with regions of excessive divergence: *e.g.* off northern Peru at Capo Blanco and the Lobos Islands, off Antofagasta and off Caldera. They were minor currents with a temperature slightly if any higher than the surrounding water. While of an eddy-like nature, they were probably in part compensatory, for in their vicinity upwelling was reduced. These eddies are coastal and cyclonic and in this respect distinguishable from the much larger swirls which are anticyclonic. Their effect on the plankton has not been fully determined.

Summary

Summarizing these conclusions, there are, besides the main body of the Peru Current which shows northerly drift and westerly set, three other current systems on the west coast.

I. Upwelling of lower layers which may be looked upon as vertical currents of compensation for surface water drawn off towards the west.
II. Off-shore, a series of large-scale anticyclonic swirls bringing oceanic counter-currents to regions of excessive divergence.
III. In-shore, a series of small coastal counter-currents, comprising a series of cyclonic eddies.

While each of these current systems shows some degree of permanence, they are obviously liable to vary within wide limits, affecting the productivity of the sea, and resulting in the formation of such spectacular manifestations as *aguaje*. Into a system of subsidiary currents such as these it is possible to fit many of the recorded irregularities and variations in the behaviour of the current that have so far eluded satisfactory explanation.

The history and nomenclature of the current are discussed. In the choice between the names Peru Current and Humboldt's Current, it is with great

diffidence that I have taken the view of the leading German authorities Hoffmann, Krümmel, and Schott in abandoning the name of Humboldt for the geographical designation. We all appreciate that Humboldt was one of the greatest oceanographers, and for this reason many of us would wish his name to be kept a household word by calling the current after him. From the historical point of view the currents on this coast, although fully recognized, were known by no names until 1837, when Berghaus published his 'Länder und Völkerkunde.' In this work he refers to it first by the name "Der Strom kalten Wassers längs der West Küste von Südamerika, geschildert von A. von Humboldt." On p. 584 this becomes contracted to "peruanische Strömung," and only in a footnote does he suggest the alternative name "Humboldt Strömung."

Humboldt's greatest contributions to the subject were three in number. He invented the isotherm; he postulated the upwelling of cold water in the Atlantic, but not in the Pacific; and by dipping the first thermometer into the Peruvian Current, he showed that the temperature of the water was lower than that of the air. It will be seen therefore that Humboldt's contribution to this particular current was not in the nature of a discovery; while his theory of a current of Antarctic origin is now almost universally abandoned. His name is mainly associated with this abandoned theory.

On these, on historical grounds, and in accordance with modern usage, it is preferable to adopt the geographical designation. There is a further reason for keeping to the name Peru Current, and that is one of convenience. The current coming under the influence of upwelling is different physically, chemically, and biologically from the more oceanic portion of the current. There is no hard-and-fast boundary between the two, but the differences are such as to require distinction. The boundary between the two regions might arbitrarily be placed where the surface isotherms run north and south instead of east and west. If the coastal region were called the Humboldt Current, a new name must be found for the oceanic drift. Whereas if the in-shore water was called the Peru Coastal Current, the off-shore may suitably be called the Peru Oceanic Current.

Acknowledgments

I wish to acknowledge my indebtedness to the Captain and Crew of the R.R.S. *William Scoresby* for their help in the earlier stages of this work, and especially to my colleague, Mr. A. H. Laurie, who shared the scientific work. I wish also to thank the *Discovery* Committee for permission to reproduce the Figures.

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[*Note.*—Owing to lack of space it has not been possible to print more than a fraction of the references relevant to this account; and for those not included in the following list the reader is referred to the *Discovery* Reports, vol. xiii, pp. 223 *et sqq.*]

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DISCUSSION

Before the paper the PRESIDENT (Major-General Sir PERCY COX) said: Ladies and Gentlemen, This afternoon Mr. Gunther, one of the staff of the *Discovery* Investigations, who has recently been on the Peruvian coast, is going to talk to us on the behaviour of what used to be called the Humboldt Current, but what, I understand, scientists now prefer to call the Peru Coastal Current. It is a subject which bristles with interesting problems, and in regard to which

different theories have been advanced at different times. At first it was believed that the current came from the north; then Humboldt suggested that it came from the Antarctic. Now there are other theories under investigation as to how it is formed. It is of extraordinary interest to find a practically desert coast subject to a temperate climate extending far into the tropics. But Mr. Gunther is going to tell us all about it, so I need not enter into it further, in what can only be a very amateur way.

Mr. Gunther then read the paper printed above, and a discussion followed.

The PRESIDENT: Dr. Stanley Kemp, who has been long associated with the *Discovery* Committee, as Director of Research, will address us.

Dr. STANLEY KEMP: You have heard to-night from Mr. Gunther some part of the results that he obtained on his cruise along the west coast of South America. This work, if I may so express it, is to be looked on as a by-product of our investigations, for most of the operations undertaken by the *Discovery* Committee are centred in the Antarctic; the cruise was made during the Antarctic winter, when our work in the south is at a minimum, and it was arranged at the suggestion of the Admiralty. The currents on this coast are not only of scientific, but of practical importance, and as you will have gathered from Mr. Gunther, they are highly complicated. Mr. Gunther did not say anything of the difficulties he encountered in carrying out this work, but I can assure you they were very real. The *William Scoresby* is a small ship with a small crew, and the making of this long series of observations all the way up the coast was an extremely strenuous undertaking. Mr. Gunther's full account of the hydrological side of the work is appearing shortly in the *Discovery* Reports, and I feel that it will be a really useful contribution to the subject.

You will have noticed that Mr. Gunther has been able to form a number of hypotheses, and some of these, when we know more about the subject, will, I believe, turn out to be right; but in any case it is a useful thing to formulate such hypotheses, if only to stimulate the further work that will be needed to knock them over. I think Mr. Gunther is to be congratulated on the lucid account of his work that he has given us.

The PRESIDENT: I call on Dr. Mill.

Dr. H. R. MILL: Although I have not been actively engaged in oceanography for the last quarter of a century it was my privilege long before that to be introduced to the science by the leaders of the *Challenger* expedition, and I was pleased to gather from Mr. Gunther that the work of Buchan and Buchanan is still considered fundamental in the theory of the somewhat mysterious currents along the western coast of South America. I am attracted by the idea of offshore winds starting upwelling of deep water, as my work on the small scale of the sea-lochs of Scotland showed that wind blowing for a few hours often turned the layers of water in a deep basin upside down. The ocean is only a one-sided basin, but my work on the continental shelf west of Lewis in 1887 showed the marked contrast of the action of off-shore and on-shore winds. Some points suggest themselves to me in listening to the extremely ingenious hypothesis which Mr. Gunther has put forward.

One of these is as to the possible effect of the land and sea breezes. I cannot recall at this moment whether on the tropical coast of South America there is any pronounced föhn effect from the winds descending at night from the snow-capped summits of the Andes, or whether the plain between the Andes and the sea is wide enough to prevent such winds from reaching the water. But there is a possibility that the land winds may always be stronger than the sea winds or that there may be variations in relative strength in different seasons, or on

adjacent parts of the coast that may have a considerable influence on the complicated movements observed.

Again, the position of areas of strong up-welling separated by areas of still water or purely horizontal currents may possibly be determined to some extent by the slope of the coast. I think that upwelling due to off-shore wind is more marked where the submarine slope is steep. On the other hand, the effect of on-shore winds in raising the temperature is more pronounced when the submarine slope is gentle. These are points which can only be elucidated by numerous and continuous observations, and I am afraid it will take a long time yet before the South American republics organize scientific work on such a scale as to settle them beyond dispute. But the way in which the Argentine Government has contributed to the advancement of meteorology by their observatory in the South Orkneys makes one hope that the future may see progress in that direction in the western republics also.

One other point. Although Humboldt's original idea of the Antarctic drift giving rise to the current towards the Equator must be given up, is there not a sense in which the water of the Peru current is Antarctic in origin? The deep cold water of the Pacific must be the result of cooling by Antarctic influence. In the Atlantic cooling from the Arctic prevails to some extent, but the Pacific Ocean is practically closed on the north and the low temperature in the depths can only come from the south.

I am particularly interested in this account of the work of the ships of the *Discovery* Committee. Although it seems a little out of their beaten track, I do hope that means will be afforded by the Admiralty to the *Discovery* Committee of carrying on the observations, and really settling a point which in its full scientific importance has a bearing on the movement of all the seas in the world.

We are extremely indebted to Mr. Gunther for the clear way in which he has described the observations he has made and the theories he has founded upon them.

Dr. H. A. MATTHEWS (Birkbeck College): In connection with this paper there are two points I would like to take up. But first I want to express my gratitude, for this study which has placed the upwelling of water on an indisputable basis, has cleared up much loose talk on the question of off-shore winds and has given us isothermal maps which go far beyond anything hitherto published. At the same time, it may be useful to examine the question of the depth at which the upwelling has taken place.

Mr. Gunther has not mentioned that his work agrees with that of the Carnegie observations in showing that this upwelling is a matter of comparatively shallow depths. In all the sections we have seen this evening the indications were that the upwelling is confined to the upper 200 metres of water. The trend of the isotherms was generally upwards in the first 100 metres and, below that, was downwards. This implies that one is dealing with a comparatively shallow phenomenon.

The next point might serve to bring some greater harmony between the two ideas of northward drift and upwelling. One hundred miles out at sea in the case of the *Emden* observations the surface temperature increased rather steadily from 30° S. to 5° S., showing that 100 miles off-shore there was a certain access of warmth which was entirely compatible with a northerly drift of water, not however water of immediate Antarctic origin. That has been put entirely out of the question because it has been shown that the Antarctic water is flowing in a current some 700 metres below the surface. Along the coast the temperatures of in-shore waters were behaving in a remarkably irregular fashion, but in that case the peaks of recurrent higher temperatures came up to the curve of tem-

perature 100 miles off the coast. In fact, 100 miles off the coast we have a current or a drift of water which in normal circumstances would be regarded in itself as an anomalous feature. These temperatures of 15° C. in latitude 20° S., and of 18° C. in latitude 4° S. are in themselves major anomalies in ocean temperatures. Inshore there appears to be also an access of warmth which is compatible with the general northerly drift. But, where upwelling is particularly marked, further abnormality is added to the current and temperatures drop some 4° C. with reference to those obtaining off-shore.

To return to the idea of upwelling as a relatively shallow-water phenomenon—and indeed 100 metres was conclusively the lowest depth to which one would refer upwelling—then the significance of the meteorological factor becomes apparent.

From a detailed study of the wind movement of this coast it is clear that far from a predominance of off-shore winds there is in fact at many of these stations a predominant on-shore wind. At Arica, in July 1912, 34 per cent. of the winds observed were on-shore (south-west) and 55 per cent. were calms. Even more so at Caldera, where, in July 1912, 64 per cent. of the winds were on-shore. The accumulation of that amount of on-shore wind was due to the sea breezes which were blowing between 2 and 9 p.m. Unfortunately the Chilians no longer publish tri-daily observations, but it is highly suggestive that at both these localities unusually high water temperatures have been recorded.

The importance of these on-shore winds is implicit in the work of the *William Scoresby* in its outward and return journey off Antofagasta. What is wanted, of course, is what we have in an ordinary meteorological research—not one mobile station, but a comparatively large series of simultaneous observations. But, failing that, I would suggest that some considerable attention should be paid to the exact time of observation because of the importance of the on-shore wind, the characteristic sea breeze of the western coast.

The PRESIDENT: It remains for me to close the proceedings, and I am sure that when this lecture of Mr. Gunther's appears at full length in the *Journal* it will be of very great value. It is, as Dr. Mill has said, most clear and lucid in the explanations and theories it brings forward, and evidently Mr. Gunther is a thorough master of his own subject. Moreover the commentaries we have had have likewise been exceedingly valuable, and we are very grateful to Dr. Kemp, Dr. Mill and Dr. Matthews for their part in the discussion. Perhaps Mr. Gunther would like to add a few words in reply.

Mr. GUNTHER: The previous speakers have raised many important points which I had not time this evening to refer to, and I am very grateful to them for having given me this opportunity of replying to them. Dr. Mill has suggested that disparities in the amount of upwelling from one locality to another might be related to the slope of the sea-bottom. While I agree that the theories formulated by Ekman would lead us to expect such a relation, its effect is probably in fact overshadowed by certain other factors whose influence is more far-reaching.

Antarctic influence cannot, I suppose, be ruled out of the Peru Current, but in its strictest sense I think it must be minimal. I am afraid I have not had time this evening to consider the nature and origin of the sub-surface currents, which of course have a fundamental bearing on the subject. Salinity determinations show that the water which wells up is drawn from a depth of between 100 and 360 metres, rather deeper than those suggested by Dr. Matthews, and comes either from sub-Antarctic water, sub-tropical water, or a mixture of the two. The Antarctic intermediate water is not touched, and in these latitudes it is the Antarctic intermediate water which bears the stamp of Antarctic influence. Deacon has shown that in the South Atlantic some mixture between

the Antarctic and sub-Antarctic water is inevitable; and inasmuch as this may happen, upwelling of sub-Antarctic water on the west coast will carry Antarctic influence. But I think it must be minimal.

Dr. Matthews, in drawing attention to the fact that isotherms below the upwelling depth when seen in transverse section, curve downwards near the coast, has actually drawn attention to a warm mid-water current which I have not had time to discuss. It represents a mixture of sub-tropical and sub-Antarctic water which is travelling southwards between the surface layers above and the Antarctic intermediate water below. This stratification of the water into recognizable layers is a useful asset since it gives us an index to the depths affected by upwelling.

Dr. Matthews, unless I am mistaken, has suggested that the steady increase of warmth shown by Dr. Schott's curve of surface temperature at 100 miles off-shore from lat. 30° to 5° S., is indicative of northerly drift which is itself to be considered anomalous. We should remember that this curve is not based on the *Emden's* data, but is a mean curve; and it is probably to this that the curve owes its smoothness. No doubt there are considerable variations in that zone. There is nothing to suggest that water 100 miles off-shore does not come under the influence of coastal upwelling, so that if the temperature of the coastal waters is similar to what it is 100 miles off-shore such irregularities might be explained. Whether or not northerly current so far from land should be regarded as anomalous I am not prepared to express an expert opinion; but from comparison of oceanic circulation in other parts of the world, it certainly looks like a normal feature of the anti-cyclonic movement.

I should like to make a final remark on the on-shore wind which Dr. Matthews has mentioned. When working in the coastal region we often came across a wind of this type, and it probably represents one of those influences of the land which Dr. Mill has referred to. On the coast they call it the *virazon*, and as far as I can make out, it comes on about mid-day and blows half-way round the compass before it finally settles down in the evening.

Dr. MATTHEWS: It is said that the on-shore winds are exceptionally well marked in the summer.

Mr. GUNTHER: I should make the point that it is a strictly coastal wind and was never met far out to sea. Whether in view of this it can be the cause of oceanic counter-currents or whether it merely modifies their point of convergence with the coast, I do not know. I should say the same regarding the possibility of a föhn effect.

The PRESIDENT: Again we thank Mr. Gunther heartily for his able paper, and hope that he will have opportunity to pursue his theories further.

THE FATE OF COLONEL FAWCETT

IT will be remembered that the last note published in the *Journal* (vol. 80, 1932, p. 153) regarding the fate of Colonel Fawcett contained the statement by Mr. Vincenzo Petrullo, which confirmed Mr. Dyott's story that Colonel Fawcett's last known camp was some five marches east of the Kuluene, about lat. $12\frac{3}{4}°$ S. Since then several persons have come forward with accounts of white men in various parts of Matto Grosso, generally alleged with various degrees of probability to be Colonel Fawcett and his companions. The following summary of these accounts has been compiled from stories contributed to the Press, supplemented in some cases by direct communications from the travellers, and checked by information received through the courtesy of the Foreign Office.

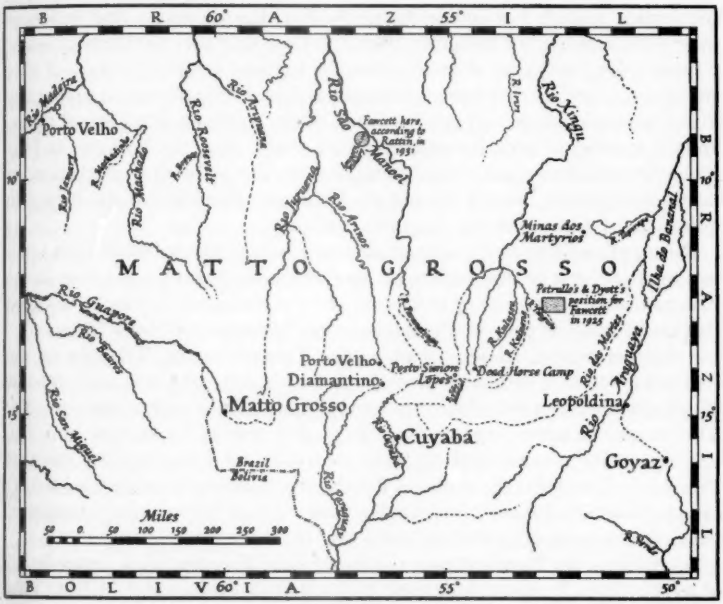
Preparations for two expeditions were mentioned in the article quoted above. Mr. Stephen Rattin, who had reported a meeting with a white man, subsequently claimed to be Colonel Fawcett, in the hands of Indians on the Iguassu Ximary, a tributary of the Rio São Manoel, returned to Matto Grosso with the intention of finding and bringing back this white captive. The scene of this meeting was approximately 400 miles to the north-west of the position reported by Dyott and Petrullo. The last news of Rattin, dating from May 1933, was that he had embarked with two companions in a small canoe at Porto Velho on the Arinos, to descend it to the Tapajoz. It seems probable that the party, said to be ill-equipped, met with disaster on the river, for no further news of them has been received.

The second expedition, led by Mr. Churchward, left England in 1932. Their object was to combine a shooting trip in Matto Grosso with an attempt to solve the Fawcett problem. As the journey has been fully described by Mr. Peter Fleming in his 'Brazilian Adventure,' it is unnecessary to narrate it in detail here. Plans were based upon information, the precise origin of which is unknown, that a Kalapalos chief had stated that Colonel Fawcett and his companions arrived at a village to the south of the Tanguro, a tributary of the Kuluene, and then passed to the eastward. For eleven days the smoke of their fires had been seen: on the twelfth, the chief setting out with supplies had reached their last camp where he found "traces of a massacre," attributed by him to Aruma Indians. This corresponded closely, so far as the locality is concerned, with the information obtained by Dyott, and little significance could be attached to the differences in minor details. The plan of the party was to descend the Araguaya from Leopoldina to the Tapirapé, a left-bank tributary, and to ascend this river in the hope of being able to reach the area in which the last Fawcett camp had been reported. On account of insufficient supplies and the approach of the rains, they were unable to carry out this programme, being obliged to turn back after travelling for three days along an unknown tributary of the Tapirapé, when at least 100 miles from their objective. As Mr. Fleming remarks, this journey was however of interest "in so far as it reproduced the conditions under which Fawcett was travelling when he disappeared." Their main difficulty was water. Travelling over the open *campo* parallel to the river course was easy, but it was necessary each

evening to cut a way back to the river through a thick belt of jungle, a task which occupied on the average two hours. They were also unable to get into touch with the Indian tribes, Chavantes or Jarumás, of whose presence there was ample evidence.

It is convenient to deal next with two accounts which appear to supplement the reports of Dyott and Petrullo, although this disturbs slightly the chronological order.

In October 1933 the Society received from Monseigneur Coutouron, of the Salesian Fathers, Lageado, Matto Grosso, a letter, dated September, 21 accompanied by a statement by Signor Virginio Pessione, whose reliability was vouched for by Monseigneur Coutouron. In the course of an expedition



to the Rio Kuluene, Pessione arrived on 30 July 1933 at an estate on the Rio São Manoel, an affluent of the Paranatinga, near the route from Cuyaba to the Kuluseu. The owners informed him that an Indian woman of the Nafucuá tribe of the Cuycúru captaincy had been living on the estate for about a year, and that after learning a few words of Portuguese, she managed to convey that she knew of the existence for several years of white men with the Aruvudu, a tribe on friendly terms with her own. The following day Pessione interviewed the Indian woman, who, with some difficulty by signs and the help of a Bakairi Indian who spoke Portuguese, told this story: When her son was still at the breast, there arrived at her village three white men and other Indians descending the Kuluene in a large canoe: one of the white men was old, tall, with blue eyes, bearded and bald; another, a youth whom she described as the son of

the first; the third was of greater age. She gave details of rings they were wearing, and also of their headgear. The elder was wearing a felt hat, his son a "colonial" helmet. (Both were wearing Stetson felt hats when they set out, but it is possible that Jack Fawcett had lost his.) She said that she saw them frequently when visiting the Aruvudu tribe at different times, the last time apparently about a year before. They were well and had learnt to speak the languages of the friendly tribes. The man with the long white beard was chief of the Aruvudu tribe, and his son was married to the daughter of the chief "Jeruata." She had borne him a child, blue-eyed and with hair the colour of an ear of millet. They occupied a small plot of arable land, but were constantly moving from village to village, gathering the children around them and drawing in the sand. When asked why the men did not leave the tribe, she replied vaguely but comprehensively that they no longer had bullets in their guns, and, more intelligibly, that they were near very wild tribes, Suyas, Cayapos, etc., and that even the friendly Indians would kill them if they attempted to flee, for they were continually watched. She then gave an itinerary to the Aruvudu captaincy; this consisted of the names of villages and tribes, and the number of days' journey separating them, along the Kuluseu and the Kuluene to Cuicuru, nine days' journey from the point of embarkation on the upper Kuluseu; one day beyond was Canapalo, which was said to be within quite a short distance of the Aruvudu captaincy.

Before proceeding to the second narrative, which throws some light upon this itinerary, one or two comments may be made. From the position on the Kuluseu assigned by Guiley (see below) to the Nafuquas, it may be assumed that the "Nafucua" tribe to which the woman belonged is Dyott's "Anauqua," the chief of whom, Aloique, had guided Fawcett to the Kalapalu on the Kuluene. Pessione estimated that the woman's son, who was said to be at breast at the time of the white men's coming, was about nine or ten years old. This might be taken to place the date of that visit at about 1925–26. The sole reason for associating these white men with the Fawcett party was that Pessione believed that the woman's details were sufficient to make the identification plausible. Pessione prepared a statement of the woman's narrative, which was witnessed by all those present at the interview.

A little later, the President received through the Foreign Office, a translation of a letter from Pessione addressed to the British Ambassador in Rio. This had been written before his consultation with Monseigneur Coutouron. It gives, with little detail, the outline summarized above, but adds that at the time of the interview he was returning from his 124 days' expedition in the region east of the Kuluene, that he had arranged for the woman to be detained, and referred to a proposed second expedition.

The next account to be mentioned is that of Mr. Paul W. Guiley, a member of the Inland South America Missionary Union, who accompanied a colleague, Mr. Halverson, on a journey to the Kuluseu and Kuluene rivers, in September 1934. His narrative is contained in his 'Report of Missionary Survey Trip to the Xingu,' for a copy of which we are indebted to the Rev. J. A. Davis. Without going into details of the journey, it is sufficient to note that after five and a half days' journey by pack train from Posto Simon Lopes (Bakairi Post of the sketch-map) the party reached the Kuluseu, down which they

continued by canoe. On reaching the junction with the Kuluene, they proceeded up that river to a village of the Kuikurus, the whole canoe journey lasting nine days. Regarding their stay at this village, Mr. Guiley writes: "Later the old chief brought to us a young boy, who is perhaps the most famous boy in the whole Xingu region. When the above-mentioned Colonel Fawcett and his son entered this region some years ago they lived among the Kuikuru Indians for quite some time, and the son had two children, a boy and a girl, by an Indian woman. The girl died, and it was the boy whom the chief brought to see us. . . . His skin was decidedly white and not Indian brown. . . . His hair, which was cropped off close to the head, was light in colour and his eyes were blue." Mr. Halverson adds to this account: "As to Colonel Fawcett we believe that he was killed on the Kuluene River, though the Kuikuro Indians told us that he had lived with them for over a year, and then had left in the direction of the Rio das Mortes."

It appears from the sketch-map accompanying Mr. Guiley's paper and the itinerary given by the Indian woman that his Kuikuru is the same as her "Cuicuru." According to the Indian account, one day farther was the Canapalo tribe: it seems likely, considering the agreement of the itineraries previously, that this is the Kalapalos of Dyott and Guiley. This therefore is the tribe which ferried Fawcett's party over the Kuluene. It is interesting to note that on the sketch-map accompanying Dyott's paper, a little north of his Kalapalos village is a Naruvotos village, and it is tempting to speculate that this is another form of the Indian woman's Aravudu, with whom, she said, Fawcett was living.

Mr. Guiley gives no reasons for his assumption that the white man said to be the father of the child was a member of the Fawcett party. The most that the two stories can be said to show is that a few years before 1934 two white men had been living with an Indian tribe on the Kuluene, about two days by canoe above its junction with the Kuluseu. It is important to note that this position is close to the area to which Colonel Fawcett was traced by Dyott and Petrullo.

The American missionaries were told that, at some unspecified date, his party had left in the direction of the Rio das Mortes. This is vague, but it could mean that they were going in the same direction as on the previous occasion when they were last seen by the Kalapalos.

In June 1933 Mrs. Fawcett received a compass belonging to a theodolite from a member of the Evangelical Union of South America. This was identified by the makers as part of an instrument supplied by them to Colonel Fawcett in 1913. It had been found near the "camp of the Bachari Indians," probably the Bakairi Post, by Colonel A. Botelho, who died soon after. Unfortunately Mrs. Fawcett never heard how it was found, or where, or the exact date. It is possible that it was one of the instruments which the return party from Dead Horse Camp is said to have brought back when Colonel Fawcett found himself unable to carry them further.

In the same month a certain Tom Roch made a statement at the British Consulate in Rio de Janeiro to the effect that during a journey in the Rio Xingu region in March–June 1933 he had found articles that without doubt belonged to Colonel Fawcett—compass, field glass, signet ring, and bag.

Fawcett had left these with an Indian tribe, the chief of which was called Asquitos. This chief told him that Fawcett was still alive, and exploring the Kuluene and neighbouring rivers in company with two other white men and three Indians. Roch further stated that he hoped in a couple of months to be able to prove that Fawcett was alive and possibly to bring a message from him.

Shortly after this, on 1 July 1933, Roch presented himself at the Colonial Secretary's Office, Trinidad, and made a statement amplifying the above. The articles were found in a hut on the "Kuelene." The Indians gave him a description of the owner "which seemed to tally with that of Colonel Fawcett," and showed him "a trace cut by Fawcett which leads in the direction of the city of Diamantura" the previous March. (This "City of Diamantura," from what appears later, is not Diamantino.) He suspected that Fawcett was somewhere between the "Rio Kuelene" and the "city of Diamantura." He gave the date as May 1933, and said the party consisted of Fawcett and five Indians.

The next development was that Roch addressed a letter, dated 22 January 1934, to Mrs. Fawcett in the care of the Society. This letter was written in very illiterate German, and was difficult to understand. Much assistance in translating and deciphering it was given by Mrs. Erika Spender. In this letter Roch went far beyond his previous statements. In November 1931 "or perhaps a little later," he was on the river "Kuelana." "This is very far in the interior, approximately on the Goyas–Matto Grosso border." Here he was detained by an Indian tribe, among whose huts he found equipment which must have come from England. He was told that these belonged to an English doctor who had been there, collecting "stones, etc.," but who was now farther in the interior, with a younger man and six Indians. He then followed the trail into the interior (from his rough sketch this was in an easterly direction) until after from three to five weeks' difficult going, he reached a mountain, near which the white doctor was living. Eventually he encountered two white men, called "Fawceth," who said they had been five years there collecting stones. Roch remained a month with them: on his departure Fawcett asked him to communicate with London, but gave no indication whether or when he would return.

It will be observed that this detailed account was written after the circulation of the Pessione report. Roch later stated that he had withheld it at Rio as he was being worried by newspaper reporters. He subsequently made further statements, with additional details, including one to H.B.M. Vice-Consul at Panama in October 1934, who was not impressed by his bearing or his manner of presenting his story. The Vice-Consul concluded however that Roch had at one time been in the interior of Brazil, but had obtained all his knowledge of the Fawcett expedition from the newspapers. It is just possible that Roch had been on the Xingu and had there picked up tales similar to those told to Pessione and the American missionaries, unless he drew all his inspiration from Dyott's narrative. On no occasion however did he produce any evidence for his alleged sojourn with Colonel Fawcett.

Prompted no doubt by the publication of the Pessione story, a number of reports about Colonel Fawcett gained currency towards the end of 1933. In

Buenos Aires, a Miguel Trucchi stated that he had seen Fawcett, and that he was a captive of the Chavante Indians on the Ilha do Bananal, the great island of the Rio Araguaya. Later he was interviewed by H.B.M. Consul at Montevideo, when he stated that he had seen Fawcett between the "Minas dos Martyrios" and the Rio das Mortes, and claimed to know that he had private reasons for remaining with the Indians. He also described how Fawcett and his companions had been felled to the ground by Indians, who however had eventually spared the former's life. Trucchi appears to have been unable to substantiate his claim to having met Fawcett, and the discrepancies in the statements attributed to him are considerable. In consequence of these reports Mr. J. C. McIntyre, an engineer who had then just returned from a six months' visit to the Ilha do Bananal, stated to the Consul at São Paulo that he had travelled extensively throughout the island and was confident that had Colonel Fawcett been there he would have learnt of his presence. He added that the island was inhabited, not by Chavantes, but by Carajas and Javahes.

At about the same time a Japanese, J. Ikissima, reported to the Consul at Para that he had obtained information on this problem. In July 1933 he had left Conceição do Araguaya with an Indian guide, who later told him that in 1932, or perhaps the year before, he had been guide to an old white man with a long white beard, who had also travelled westwards from the Araguaya, and had not returned that way. The guide did not know whether he had gone on in the direction of the Xingu or of Matto Grosso.

Later on the chief of an Indian *maloca* told Mr. Ikissima that three white men were living in another *maloca*, several days' journey beyond. They were described as Italians, but he did not attach any importance to this; on no other grounds than these he believed the old white man to be Colonel Fawcett, and the three men the united party. Conceição is some 300 miles north of the northern end of the Ilha do Bananal.

A third statement was made by Mr. A. de Winton Jones, who had arrived in Pará in February 1933, and gone into the interior. On his return in November he claimed to have spoken to an old Indian of the Boróro tribe, who told him of a white man, whose description tallied with that of Fawcett, who had passed through his tribe in 1930. Later he amplified this statement: he had followed the Rio das Mortes south "for months," and had had news of a white man with a few Indians who had come to the west bank in 1929–30, and had returned to the Xingu. He added however that he had learnt nothing definite about Fawcett. (There is an "Aldeia Bororo" some 100 km. south of the Rio das Mortes.)

In March 1934 de Winton Jones was in Cuyaba preparing another journey to seek for the Fawcett party. This time he entered the region from the south, more or less on Fawcett's and Dyott's tracks. The next news of him was a Press report that a message asking for help had been received from him by the U.S. Consul at Rio and the Brazilian Government. This stated that he was in the hands of the Inaurita Indians. It was not stated how this message had been transmitted.

Some light was thrown upon his possible fate by the report of Mr. Guiley, to which reference has already been made. He states that de Winton Jones'

guides returned in August, having quarrelled with him and deserted. Later the Nafuquas said that he had stayed with the Kalapalos on the Kuluene river, who had poisoned him, and sent him down stream to the Kuikurus. These in turn had passed him on to the Kamiyuras, since when nothing had been heard of him. The Tsuwas however said that he had recovered, and was on the way down the Xingu to Pará. The Kuikurus maintained that the Tsuwas were lying, and that de Winton Jones was dead; the latter however stuck to their story. Since then no news of the traveller has been received.

The latest attempt was that planned by the brothers Patrick and Gordon Ulyatt. On a previous expedition, a report of which appeared in *The Times* in August 1935, they had made a somewhat adventurous journey from Porto Velho on the Rio Madeira eastwards into the area between the Branco and Machadinho, tributaries of the "Rio Roosevelt." Porto Velho was the starting point of one of Colonel Fawcett's former expeditions, and Mr. Ulyatt formed the opinion that he was in this area ringed round with unfriendly Indian tribes (though he gave no reasons). Mr. Ulyatt therefore proposed to return to South America to organize a further expedition, having been allowed by Mrs. Fawcett to examine her husband's diary of the 1920–21 journey, which contained information regarding the Xingu river and its tributaries.

It cannot be said that the journeys and reports of the last few years contribute definitely to the solution of the problem. Those which are better established merely confirm the fact reported by Messrs. Dyott and Petrullo, that Colonel Fawcett's last known camp was several marches east of the Kuluseu. It is difficult to form any opinion how far they substantiate the presence in that locality of members of the party several years after they entered it

REVIEWS

EUROPE

A DESCRIPTION OF THE WESTERN ISLANDS OF SCOTLAND, *circa* 1695, by MARTIN MARTIN, Gent.: including A Voyage to St. Kilda, by the same author and A Description of the Western Isles of Scotland, by Sir DONALD MONRO. Edited with Introduction by DONALD J. MACLEOD, O.B.E., M.A., D.LITT., Officier d'Académie. *Stirling: Eneas Mackay* (1934). $7\frac{1}{2} \times 5$ *inches; 540 pages; map.* 10*s* 6*d*

A pedantic critic of small faults in a work often overlooks what is of real value. This is illustrated by Boswell's comment in 1774 that "Martin's book is a very imperfect performance, and he is erroneous as to many particulars, even some concerning his own Island" (Skye). The three subsequent editions of this book are evidence of its high value. If we except the modern accounts, works on the Western Islands are rare, and Martin has given us a comprehensive geographical description of all the islands from Arran to Lewis as well as the Orkneys and Shetlands. He not only gives a physiographic account of the various islands, but treats in even greater detail of the activities of the inhabitants, adding much that is usually omitted in modern descriptive geography. We are told of the physical attributes of the islanders, their racial origin, their language, their religion, their method of worship, their ailments and cures. We read a great deal about land tenure, methods of cultivation, and land utilization. The latter is of particular interest at this time in view of the recent publications of the Land Utilization Survey, which has recently issued several maps of the present day land-use of the area. Martin deals with each island in turn, and, although his style is somewhat monotonous, the reader is fascinated by the wealth of detail that re-creates all the everyday happenings and beliefs of these virile people. We see something of Martin's own outlook in the short chapter entitled "A particular Account of the Second Sight, or Faculty of foreseeing things to come, by way of Vision, so common among them." We also see to what extent the Western Islands had become anglicized even at that early date, and in what measure they were already looking to a government for help. Martin pleads for two agriculturalists from the Lowlands to live in each parish, with a view to the improvement of agriculture and the consequent prevention of unemployment and of further emigration. He suggests that if the natives of the Western Isles could be taught to drain, manure, and enclose and grow a greater variety of crops in order to provide winter feed for the stock, they would then be able to supply bread to the mainland. He also pleads for a government subsidy to establish the fishing industry, and he suggests that Skye is the convenient "geographical" centre.

Martin's description of the Western Islands of Scotland is followed by an account of the "Voyage to St. Kilda, the remotest of all the Hebrides," and of all he learnt during his visit to the island (1697). His account of the natural conditions, the communal organization, and social life is of special interest in view of the fact that the Islanders were evacuated by the Government in 1930 (see *Scottish Geographical Magazine*, 1930, p. 358). Martin emphasizes their lack of contact with the mainland and other islands. He estimates the population at 180, and speaks highly of their physique and freedom from disease. The volume closes with the earliest description of the Western Isles, from personal observation, by Sir Donald Monro, High Dean of the Isles. This makes more difficult reading, as the original spelling has been kept. Sir Donald Monro

visited the islands in 1549, but his account was not published until 1774. It is encyclopaedic in character, with brief details of 209 islands, and he writes more fully of those islands of which he has greater knowledge. This earlier account constitutes a valuable record and inventory of the Western Islands in the mid-sixteenth century, but lacks the vivid description and human interest of Martin's much fuller account of a century and a half later.

So many of the problems Martin mentions are the problems of to-day, that the results of his close personal observation are of great value to all interested in the Western Isles, while, at the same time, the descriptions of the life and thought of the people make the book a delight to the general reader. D. K. S.

COMPANION INTO OXFORDSHIRE. By ETHEL CARLETON WILLIAMS. *London: Methuen and Co.* 1935. $7\frac{1}{2} \times 5$ *inches;* x+268 *pages; illustrations.* 7*s* 6*d*

It is as a historical and architectural companion that this attractive volume should be taken by the wanderer through Oxfordshire villages. The author knows both these sides of her subject well and often plays off one against the other; for instance, the east windows of Forest Hill Church are the deeply splayed triple lancets which shed light on John Milton and his bride as they stood before the crimson velvet altar frontal that is still to be seen in the building. Very wisely has Oxford itself been excluded from the scope of the book; but not a few Oxford men will be glad to be taken back to the rambles of their undergraduate days. The author's declaration that it is often said that, apart from Oxford, Oxfordshire is uninteresting has surely been put up only for the pleasure of knocking it down—a process thoroughly accomplished both by the text and by the well-selected photographs. The bibliography does not include two important modern books, 'The Natural History of the Oxford District,' edited by J. J. Walker, 1926, and the 'Regional Planning Report on Oxfordshire,' 1931.

J. H. R.

PREHISTORIC MAN IN IRELAND. By CECIL P. MARTIN. *London: Macmillan and Co.* 1935. 11×7 *inches;* xii+184 *pages; illustrations.* 21*s*

In these days of rapidly expanding knowledge of Irish pre-history, a book of this kind is particularly opportune and welcome. Apart from the historic material which he has investigated, the author has examined and measured, or re-measured, all the available Irish pre-historic skulls, including those from Kilgreany which he is inclined to place in late-glacial times, and skulls from the 25-foot raised beach and sand-hill settlements, megalithic monuments, short cists, and crannogs. He concludes that the raised beach man was an offshoot of the Kilgreany race and that Ireland during Early Neolithic times had representatives of the middle group of Huxley's river-bed type. The invading Iberian people, like the earlier race still present in the West, were followed in the Early Bronze Age by a third race of round heads quite different from the preceding types and this in turn by Iron Age invaders. He identifies the last three races with the Firbolg, Danaans, and Milesians of the Annals, and concludes therefore that these have considerable historic importance.

Despite his hesitant knowledge of Pleistocene events, his somewhat discursive style, and the serious blemish of innumerable misprints which involuntarily raise doubts whether the figures of anatomical measurements fared any better in the proof reading, the author has rendered pioneer service to Irish archaeology. If his conclusions, as he readily admits, can only be tentative at this stage, his material with its full bibliography at least provides a useful basis for future studies.

J. K. C.

AN OUTLINE OF EUROPEAN ECONOMIC DEVELOPMENT. By ROGER H. SOLTAU. *London: Longmans, Green and Co.* 1935. 9×5½ *inches;* xiv+308 *pages; illustrations and maps.* 7*s* 6*d*

Professor Soltau has essayed a very difficult task—to give a coherent historical account of the development of the Western European economic system from the Roman Empire to the present day in a form suitable for the matriculation student and the general reader. When it is remembered how economic, political, and social phenomena react upon each other, and the extent to which developments in the outside world, particularly in the United States, must be taken into consideration, his ability to present lucidly so large a body of facts appears the more remarkable. He has achieved this by dividing his subject into seven periods—the Roman, feudal, and medieval ages, the age of expansion, the age of commercialism, the iron and steel age, and the present age—and by ignoring the minor differences in the several West European countries. His chapters bring out clearly the underlying movements in economic history, without attempting to present a mass of confusing detail. Though it would no doubt be possible to criticize minor points or omissions, his work as a whole appears soundly based: he has certainly familiarized himself with many of the results of modern research. G. R. C.

GEOLOGIE VON EUROPA. By SERGE VON BUBNOFF. (Geologie der Erde. Edited by ERICH KRENKEL.) Zweiter Band: Das ausseralpine Westeuropa. Zweiter Teil: Die Entwicklung des Oberbaues. *Berlin: Borntraeger* 1935. 10½×7 *inches;* x+693–1134 *pages; diagrams and maps. M.*32

The two earlier parts of this monumental work were published in 1926 and 1930 respectively. Dividing the continent of Europe on an altogether novel but fundamentally scientific plan the author has now produced a book which in comparison with analogous works may seem strangely limited in scope. It might be described as covering the post-Palaeozoic stratigraphy of Europe north and west of the Alpine Chain. In the first part of the second volume the history of this part of Europe was traced through its troublous youth during the Caledonian and Variscan revolutions: now we follow its peaceful maturity, only faintly disturbed by the Alpine upheavals. Consequently this part is almost pure stratigraphy, with very little tectonics, in marked contrast to the preceding part.

Such a work must needs be in great measure a compilation, and its value must depend on the critical judgment of the author on the work of other geologists. Testing this by a few British cases we consider that the author has summarized a complicated series of facts very successfully. One criticism must be made: statements of stratigraphical succession are sometimes made in ascending, sometimes in descending sequence, though the worst danger of misunderstanding is avoided by numbering the series always from below upwards. In English publications a descending sequence (with upward numbering) is now universally adopted. We congratulate Professor von Bubnoff on a great achievement and trust that he may long be spared to carry on his survey over the rest of Europe. A. M. D.

A WAYFARER IN NORWAY. By SAMUEL J. BECKETT. *London: Methuen and Co.* 1935. 7½×5 *inches;* xiv+208 *pages; illustrations and sketch-maps.* 7*s* 6*d*

This addition to the Wayfarer Series is written with insight and knowledge. The author recalls the days when a journey in Norway was still something of an adventure. Now, with the frequency and efficiency of the ordinary mail-boat and postal steamer service on the Norwegian coast it is possible to see Norway

thoroughly and in comfort. Mr. Beckett deals mainly with more superficial aspects of the country, and he does not do more than touch upon the east, where more land is under cultivation and the scenery is quieter and less romantic. But for the leisured traveller, who desires to know something of the people as well as the country, there is much to be seen in the less-frequented districts.

The author gives a sketch of Norwegian history. His archaeological and geological notes are brief and valuable. Local customs and dress are adequately dealt with, and Norway's "high spots" are all visited and described. It would be difficult to find a more useful and interesting companion for a tour in this remarkable country. M. L.

ASIA

PALESTINE OF THE ARABS. By Mrs. STEUART ERSKINE. *London: George G. Harrap and Co.* 1935. 9×5½ *inches; 256 pages; illustrations and sketch-map.* 10*s* 6*d*

Mrs. Erskine has obviously studied the situation in Palestine at first hand and shows considerable loyalty to her Arab hosts in what is a careful statement of the case against Zionism from a Nationalist Arab point of view. The argument is, briefly, that the hopes of independence held out to the Arabs in the early part of the war, in return for military assistance against the Turks, have not been fulfilled in Palestine, and that the reason for this is to be found in the Balfour Declaration. Mrs. Erskine deliberately neglects the economic prosperity brought to Palestine by Jewish immigration. This attitude is typical of the extreme Nationalist section of opinion represented by the wealthier Arab element; but there is little or nothing to show that this indifference is shared by the population at large.

The solution suggested is the division of Palestine into an Arab and a Jewish Canton, with the cities associated with the three religions under some form of neutral or international administration. While this solution would bring with it certain obvious advantages, it calls for subdivision of what is a very small country which should, in the long run, be able to settle its internal problems on a more peaceful and friendly basis. The book cannot be considered an impartial review of Palestine, but may be found useful as stressing certain points which are not always treated at length in pro-Zionist publications; as such it not unnaturally errs at times on the side of excessive "shepherd and peasant" romanticism. I. B.

SECRETS OF TIBET: Being the Chronicle of the Tucci Scientific Expedition to Western Tibet (1933). By GIUSEPPE TUCCI and E. GHERSI. Translated by MARY A. JOHNSTONE. *London: Blackie and Son* 1935. 8½×5½ *inches;* xiv+210 *pages; illustrations and map.* 15*s*

Tibetan lamaism exerts a dominant influence far beyond the borders of Tibet itself. Investigation of this form of Buddhism has for a long time been delayed in favour of the more accessible Indian professions of the faith. It has in fact often been stated that in Tibet there ruled a depraved Buddhism, containing large elements of the earlier naturalistic Bon religion.

The publication of Evans-Wentz's 'Tibetan Yoga and Secret Doctrines' (reviewed in the *Journal Roy. Centr. Asia. Soc.*, January 1936) and the researches of the authors of this book point to a new valuation of the tradition still preserved in Tibet. These and Marco Pallis, an Englishman now working in the same field, have realized that without "intimate comprehension of the *realia* . . . it is difficult to understand fully the significance of Tibetan literature and art."

To continue to quote the author's introduction, a research worker in Tibet must "have time and means to acquire that Buddhist culture and that profound and direct knowledge of India and its civilization without which it becomes difficult to understand and assess many of the cultural and historical manifestations of Tibet."

In this book one realizes the kind of work Dr. Tucci is carrying out and his exceptional qualifications for doing it. Where others have had to be satisfied with what the Tibetans were prepared to show, Dr. Tucci has used every ruse and device to force from the inhabitants information and privileges they did not in the least want to give. More than an objective understanding of the people is needed for this; in fact, all through the book we have evidence of a profound sympathy for the Buddhist mode of thought. So that although this book is written as the diary of a rather tiresome journey through stupid and obstructive people, there appears now and then a passage instigated by a painting or an incident that gives one a glimpse of that other world, different physically as well as spiritually, in which the learned Tibetans live. "They risk themselves," he says, and we should note the word risk, for the Western concept of asceticism is rather a retreat into a safer world, "in introspection and practices which excite and develop to perfection faculties and powers which certainly are not prerogatives limited to them; but, amongst ourselves, with our habit of always living in the public eye and never in solitary communion with ourselves, they have no chance of manifesting themselves." These powers are acquired during meditation by a long apprenticeship and through complicated control of breathing. Both the books mentioned agree in confirming the contention that the Tibetan ascetics can control forces of the ego of which only the psychologists of Western civilization have any knowledge, and that very imperfect.

The book is an account of a journey into Western Tibet carried out in 1933 and is written as a guide for future travellers. The real results of the expedition are to be published in the series Indo-Tibetica, published in Rome. A travel diary is a tedious literary form and the translation is not good, such mistranslations as Foreign Secretariat for Foreign Office and carriage for lorry seem to betray a long-standing lack of familiarity with English. But the traveller would find much of value in the book, not the least valuable being the plentiful supply of Tibetan words. The pictures raise the book to the level of a work of reference, since rarely has such a collection of photographs of statues, frescoes, and printings been available. When one remembers in what a murky gloom these works of art are usually confined one realizes that somebody has been very skilful with his camera.

M. A. S.

THE PROBLEM OF JAPAN. By CAPTAIN MALCOLM D. KENNEDY. *London: Nisbet and Co.* 1935. 9 × 5½ *inches;* xvi + 288 *pages; illustrations and map.* 15*s*

Captain Kennedy is as well qualified as any man living to write on the subject of Japan, and he presents her problem in a manner that is straightforward, lucid, and objective. His work forms indeed an admirable statement of her complex case as considered from the standpoint of one who is a soldier and a political realist. Political realism however implies an essentially materialistic view of world politics, certain limitations of prospective, and a tendency to stress the immediate present while ignoring the past and its lessons and the future and its hopes. The author is moreover a specialist on the subject of Japan, and, like specialists in every branch of human activity, he tends unduly to emphasize the importance of his own sectional interest instead of considering it in its relation to the whole system of which it forms a part.

Might the author not take a wider view of these things than his book would

seem to indicate? It is for instance a creditable fact that the history of China, if marked once in every thousand years by a century of disorder, is in the main a history of static conditions and able government; that in every country politics, when first democratized, are almost invariably corrupt; and that the forcible acquisition of the land of weaker nations is not now so highly esteemed by world opinion as it was so recently as a quarter of a century ago.

But perhaps the intricacies of the problem that Captain Kennedy expounds so ably—if, one might say, so narrowly—are already enough for the compass of one book; and his work, and particularly the portion of it which deals with Manchuria, is to be commended to the serious attention of all those who wish to study that problem in detail. For the author has cut the many difficult facets of his diamond brilliantly; one could only wish that he had given it a more ample setting.

AFRICA

MY PYGMY AND NEGRO HOSTS. By PAUL SCHEBESTA. Translated from the German by GERALD GRIFFIN. *London: Hutchinson and Co.* 1936. 9½×6 *inches;* 288 *pages; illustrations and maps.* 18*s*

This book, primarily written for the non-specialized reader who is interested in the habits, beliefs, and relationships of the primitive peoples inhabiting a part of Africa seldom traversed, nevertheless contains much information of value to students. Those who have read the author's former work 'Among Congo Pigmies' will find unflagging interest in the present volume. It deals with that part of the Congo basin extending from the Equator to lat. 3° N., and from near the western edge of the Western Rift Valley to the longitude of Stanleyville. The book is devoted almost entirely to the study of the natives and knowledge has been acquired in a most painstaking manner. There is much to interest the general reader, especially perhaps the account of the secret society of the Anyoto or Leopard men, who operate in the Babali country or upon its confines, in the west central part of the basin studied. The Anyoto are cannibals, and one is struck in reading the book with the frequency the author records the survival of this custom, elsewhere practically exterminated. It is characteristic of the complexity of African institutions that the Anyoto are connected with the ritual of the making of the tribal marks (Mambela), which take the place of circumcision, and the use of what the author refers to as the "whirring-wood," presumably the bull-roarer. Moreover the emergence of the Anyoto from obscurity coincided with the encroachments of the Wangwana, an eastern tribe professing Muhammadanism, and in the first place originated amongst the Bafwasia, a clan of the Babali, noted for their iron ores and blacksmiths, both necessary for the manufacture of the iron claws which sheathe the fingers of members of the Society when on murder bent. The author believes that the Anyoto were inaugurated as a protest and a mental relief against the exploitation by the Wangwana and later by Europeans of their lands and people. The Wangwana penetrated into the Ituri forest about fifty years ago and their language is now the commercial tongue of the greater part of the Belgian Congo. In 1915, after lording it over the Babali, they were introduced to a more orderly mode of life by the Belgians. The account of the Babali and the Wangwana forms only a fraction of the book: noteworthy also are the pages dealing with the hybrid Bachwa and the negro Nkundo, their overlords. Many of the customs and habits of the latter are now adopted by the former, another instance of the obliteration of earlier faiths by changing conditions. Individuality is being only too rapidly lost.

Of the Belgian administration little is said, as being beyond the scope of the book, but while the writer is clearly sympathetic with the rights of the natives and comments on the apparent uselessness to them of the making and upkeep of roads he is assured as to the consideration and justice now given by the Belgian Government to the "interests and welfare" of the native communities. Admittedly, as he says, "colonization never was and never will be prompted merely by altruistic motives," and expresses the opinion that the deleterious effect of European civilization in the past was largely due to assuming the primitive peoples were devoid of what he terms "culture." Bearing in mind the difficulty the native has in realizing the why and wherefore of the white man's doings, the author would blend the best elements of the aboriginal and incoming "cultures" to effect the wisest Government.

It must be remarked that the value of this book would be materially increased by better maps than the two small-scale sketches, sprinkled with often all but unreadable names, which have to serve the reader's turn. The plates are excellent and the index adequate, points which emphasize the need of legible plans showing clearly the author's route and the geographical features of the country he visited.

The use of "coco-nut" for the oil-palm nut is misleading and by "earth-nut" is presumably meant ground-nut. J. P.

NORTH AMERICA

PUBLIC SCHOOL EXPLORERS IN NEWFOUNDLAND. By DENNIS CLARKE. *London: Putnam* [1935]. 8½×5½ *inches;* xii+294 *pages; illustrations and maps.* 10s 6d

Nowhere in this book could the reviewer find a year date: only by research was it possible to discover that it describes not the 1935 expedition to Newfoundland but that of 1934. This is a most tiresome omission since an expedition book must at least be a proper record.

Mr. Clarke was a journalist who joined the expedition in order to be able to make this chronicle. His account runs easily enough, in the manner of a Fleet Street man fearful of boring his readers. For some, such devices may be necessary when describing the voyage on a liner to St. Johns, especially if fifty pages must be covered before the expedition begins moving on its own account. But when he records a journey on which he himself took part this very facility makes it hard to believe that he really felt what he describes. If a writer once assumes bravado or ignorance he thenceforth denies the reader the opportunity of re-living the days of marching through swamp and forest.

So much for the narrative. The expedition's primary function is presumably not to explore but to introduce boys to the life. This is something valuable for science and exploration generally. If a little exploration can be thrown in, then so much the better. Certainly the 1934 achievement of mapping and collecting was creditable to all concerned and the appendices written by the boys are excellent. Another appendix written by the leader, Surgeon-Commander Murray-Levick, R.N., shows that food and equipment (30 oz. man-day ration: 2½ lb. sleeping-bag) were well planned.

The reviewer understands that these expeditions, which give the boys about a month in the field, cost about £40 a head. The kind of country traversed and the discomforts encountered could probably be obtained closer at hand in the more accessible parts of Sweden or Finland. Is the choice of Newfoundland (*a*) worth the extra cost; (*b*) worth the risk of cultivating a bogus emotion that

scientific work in "untrodden" country is more valuable than that carried out in known parts? Possibly all is well so long as the word "exploration" is not too heavily stressed. In all events there will be many expedition leaders who in the future will have cause to thank "The Admiral" and his excellent team of assistant leaders for the start they gave their men. M. A. S.

CENTRAL AND SOUTH AMERICA

DER GRAN CHACO UND SEINE RANDGEBIETE. By HELMUTH KANTER. (Hansische Universität. Abh. aus dem Gebiet der Auslandskunde. Bd. 43—Reihe C. Bd. 13.) *Hamburg: Friederichsen, de Gruyter and Co.* 1936. 11½×8 *inches;* xii+376 *pages; illustrations and maps. M.*18

This book sets forth the results obtained by the author during a journey of some 10,000 miles, mostly on muleback, in the Gran Chaco, recently the scene of a disastrous war between Paraguay and Bolivia. The southern half of the Gran Chaco forms the northernmost part of the Republic of Argentina, the boundary being the Rio Pilcomayo: the division of the northern half between Paraguay and Bolivia is obviously still uncertain.

However the physiographical boundaries of the region, a matter of more permanent interest, are fairly definite: in broad terms it may be said to extend from the eastern foothills of the Andes to the Rio Paraguay: to the east of this river the land soon begins to rise to the highlands of Brazil. Considering its distance from the sea, in the middle of a great continent, it is rather surprising to find that almost the whole of the Chaco lies below the 600-foot contour. This low general level, combined with a warm climate and the presence of a vast mountain chain on the west, gives rise to some remarkable geographical features, which are largely controlled by the distribution of the rainfall. According to a diagram given by the author the precipitation in the plain of the Paraguay is fairly heavy, about 1200 mm. Towards the west this decreases, with a minimum of 400 mm. just north of Clodomira. Again beyond this is found a remarkably rapid increase to 2000 mm. (nearly 80 inches) to the south-west. It must always be remembered however that an absolute value for the rainfall of any region does not convey much information unless the average temperature is also taken into account. Thus many parts of both South Africa and Australia, of a markedly arid character, have an actual rainfall as great as, or greater than, that of parts of eastern England, which are by no means barren lands, and indeed appear to the inhabitants thereof to be for the most part of the year unpleasantly damp. It may be suggested that average rainfall divided by average temperature would provide a useful index figure for climatological purposes with an obvious practical application.

From this point of view the most interesting region of the Gran Chaco is the western half, where the rivers fed by the heavy rains of the eastern Andes descend into the hot dry plains by a rapid gradient. Here are developed the peculiar and characteristic geographical forms so well described by the author of this book. To put it shortly and in simple words, when the rivers from the mountains come down to the hot plains below, they dry up. The most notable feature of the western Chaco is the enormous number of dry, or nearly dry, river beds.

From his observations the author characterizes a large number of geographical types of country, of which the following are the more important. On the western dry side: thorn-bush forest; dry forest; park land; damp steppe park land (it may be asked incidentally, what is a damp steppe?); dry steppe park

land. On the east side he distinguishes the river districts; flooded grass areas; the quartzite plateau of the north; sandstone steppe hills; forest plain; the *inselgebirge* region of Corumbá; and tropical damp steppes. It must be admitted that in many instances the general nature of the author's conclusion is apt to be lost in a mass of detail. In this review no attempt is made to deal with the settled southern part of the Chaco, but it is clear that in the west and north there are remarkable variations of type ranging from dry basins with salt-pans and no outlet, through every variety of steppe and thorn-bush to flooded and impenetrable tropical jungle with palms and lianas in the east. Geologically, so far as can be seen, the country seems to consist of blocks of the old Brazilian Shield, overlain by sediments of the ubiquitous Gondwana facies (Permian and Triassic) with some Cretaceous. The book closes with short chapters on vegetation, animals, and man. R. H. R.

A DESCRIPTION OF PATAGONIA AND THE ADJOINING PARTS of South America. By THOMAS FALKNER, S.J. Edited by ARTHUR E. S. NEUMANN. *Chicago: Armann and Armann* 1935. [Facsimile reprint of the original edition. *Hereford:* 1774.] 11 × 8 *inches;* iv + 168 *pages; map.* $6.00

Considering the number of people who had a hand in composing this book it is perhaps surprising that it has turned out so well. Falkner certainly did not write the book; nevertheless its value, for it had when first published, and has still, a considerable value, must be ascribed entirely to him. The Rev. Joseph Berington, as quoted by Mr. Neumann, said on the appearance of the book, "Father Falkner was a man of vigorous mind . . . and, had he been allowed to tell his story in his own way, stored as his mind was with anecdotes and incidents on which he delighted to dwell, we should have had from him an amusing and interesting performance. But his papers were put into the hands of Robert Berkeley, of Spetchley, Esq., who extracted from the whole the spirit of the original, and made them what they are." But even this is not a full statement of what happened: Berkeley did not write the book, though he wrote a long introduction to it; but he employed to write it a quite unknown man, who was perforce leaving off the occupation of roué and taking to that of journalism. This was William Combe, afterwards associated with Rowlandson in the production of 'Doctor Syntax' and other profusely illustrated books. At Berkeley's suggestion he tried his prentice hand on Falkner's papers; and though the result pleased neither Falkner nor his friends, there is no reason to suppose that Combe's compilation was other than a conscientious piece of work.

Falkner was born in 1707 and brought up to the medical profession. In 1731 he went out to Africa in an Asiento ship, *i.e.* a slaver, and when she reached the River Plate was so ill that his captain left him at sick quarters in the Jesuit College at Buenos Aires. There he was cured, and was also converted. Henceforward he was a medical missionary, with a strong taste for travel. For some years he was employed in Paraguay, and to the westward, north of the present transcontinental railway, and it was not till after 1740 (Combe eschews dates) that his association with Patagonia began. The very title of the book is not his, and it is doubtful whether he agreed with Combe in calling the whole country from the River Plate to the Straits of Magellan by the name of Patagonia.

The first Jesuit mission station south of the Plate was founded at C. San Antonio in 1740, and very soon its founder reported to the College that the Indians held that a priest ought also to be a medicine man. He asked them to remove this handicap, and their answer was to send Falkner to join him. How long Falkner remained among the Indians does not appear. Mr. Neumann infers that his stay "did not exceed 20 years in all"; the *Dict. Nat. Biog.* says

thirty-eight years, which is certainly an overstatement, for but thirty-six years intervened between his reception into the order and his return to England on the expulsion of the Jesuits from the Spanish colonies. Falkner travelled widely over the northern and especially the north-eastern parts of the extended Patagonia, and made notes of everything that interested him. He accompanied a Spanish expedition sent in 1746 down the east coast to the Straits of Magellan, but apart from this was apparently never south of the Rio Negro. As may be judged from Falkner's map, the survey of the coast in 1746 was perfunctory.

As a geographer Falkner was interested rather in the description of physical features than in the determination of positions. Thus he describes the rivers, the woods, the deserts, the lakes, and salt-pans, with considerable accuracy; the mountains are much more generally treated, because for the most part they lay outside that part of the country of which he had personal knowledge. For them, as for the archipelago of Tierra del Fuego and of the west coast, he had to rely on hearsay, and wisely did not pretend to accurate knowledge. It is noticeable however that the longitudes of his map are wildly erroneous, and also that he has greatly exaggerated the width of the continent. By bringing the Falkland Islands 2° too near the Straits, he has placed them due south of C. Blanco. Now by the time the book was written, in 1774, the problem of the longitude was on the way to being solved; and it is likely that, had Falkner been allowed to be his own editor, he would have taken pains to find a few corrected positions from which to revise his map. But evidently neither Squire Berkeley nor his employé Combe had an eye for such niceties.

But the greater part of the material is drawn from Falkner's notes on the Indian tribes, their way of life, their religion, even their language. To these must be added his collections on natural history, especially on the fauna and flora. A century ago Captains King and Fitzroy found the book useful and informing; it is likely that ethnologists and naturalists will still continue to find it so.

Mr. Neumann's notes would have been welcomed by Falkner himself as worthy of the pains he expended in the collection of material. The present edition is a facsimile of the eighteenth century original, differing from it only by the addition of Mr. Neumann's short introduction and copious notes.

L. G. C. L.

AUSTRALASIA AND PACIFIC

REPORTS OF THE CAMBRIDGE ANTHROPOLOGICAL EXPEDITION to Torres Straits. Volume I. General Ethnography. By A. C. HADDON. *Cambridge: University Press* 1935. 11½×8½ *inches;* xiv+422 *pages; illustrations and maps.* 40*s*

Dr. A. C. Haddon is not the only zoologist who has widened his horizon by limiting his field of study, but it would be difficult to name another who has shown himself more worthy of promotion from animals to man. Since the time when, in 1888, already a Professor of Zoology, he went to the Torres Straits to study the local fauna, and found the Islanders as magnetic as their rivals in the sea, until the present day, when he is honoured as the doyen of British Anthropology, he has spent a working lifetime of devotion to the subject which chose him for its own. In the beginning there was some reluctance on his own part, and not too much incitement from without, but his impetuous spirit broke down these barriers, and in 1893 he left Dublin for Cambridge, with a view to making closer contact with others who pursued the proper study of mankind. Ten years after his first visit to the Torres Straits he was back again,

but this time his dredges and his tow-nets were replaced by psychologists, a linguist, a technologist, and a medicine-man. His wisdom in the choice of the colleagues whom he sought to make fishers of men is shown in the outstanding contributions to anthropology and other sciences that have since been made by them. The fertilizing effects of even a short spell "in the field"—the expedition was only some six months in the Torres Straits—seem to be unlimited, and the expedition may be said to have given birth not only to the six volumes of Reports, of which this is the first and the last, but to books and papers on the Melanesians, the Todas, the Veddas of Ceylon, and other peoples; and on physical anthropology, linguistics, kinship and social organization, magic and religion, material culture, and in fact upon most of the diversified subjects with which anthropology is concerned. Not even Dr. Haddon himself could cover all this ground, but to the stimulus of the expedition, which is a landmark in the history of anthropology, may be attributed many years of fruitful work by those who accompanied him. He himself, whilst covering a wide range of subjects as investigator and as teacher, has made the ethnography of New Guinea and various branches of technology the special objects of his interest, though he has not neglected the physical characters of native peoples, nor their beliefs and customs. The Cambridge Anthropological Expedition has in fact had far-reaching effects upon the study of anthropology in this country, and it is the more noteworthy inasmuch as it is an example of individual enterprise in a field in which strong Government support should be but is rarely forthcoming.

This volume of the Reports is a bringing together of threads, and it includes much new information obtained partly by Dr. Haddon himself when he was again in the New Guinea area, and partly by the investigations of MacFarlane, Landtman, Chinnery, Riley, Bruce, and others. An Introduction dealing briefly with the constitution and aims of the expedition is followed by an historical sketch of the first European contacts, by no means always peaceful contacts, with the Islanders. Then follows an account of the Geography and Geology of the islands. The synopsis of the ethnography of the individual islands contains much new information, as does also the account of the ethnography of neighbouring areas—Western Papua, South Netherlands New Guinea, North Queensland—full advantage being taken of the work of Landtman, Wirz, Thomson, and others. The conclusions are drawn that it is to south-west New Guinea that the Torres Straits Islands owe most of their culture, and that reciprocal influence has taken place between North Queensland and the Torres Straits. The sketch of the Ethnic History of Papua-Australia discusses the problem of the peopling of the area, and in conclusion the author says, "I candidly admit that the foregoing is highly theoretical but at present I have no better hypothesis to suggest." No anthropologist will be surprised that Dr. Haddon refrains from dogmatism on this question, but his treatment of a very difficult problem will arouse their interest and their sympathy.

Part III deals with the General Ethnography of Torres Straits, including Physical Anthropology, Psychology and Behaviour, Languages, Folk Tales, Material Culture, Disposal of the Dead (including a very interesting discussion of mummification, not too diffusionist in tendency), Head-hunting, Dugong and Turtle hunting, Religious Concepts, Objects, and Rites, Culture-bearers, Cult-heroes, and Hero-cults, and a Summary of the Culture-history of Torres Straits.

From the foregoing it will be clear that to review this volume, in an appraising or expository sense, would be to make unreasonable demands on the space of a journal that is not primarily devoted to anthropology. It must suffice to say

that the Report is worthy of the Expedition, of the University of Cambridge, and of its author. Those who possess the five volumes already published will naturally acquire this one, but it is in many respects so self-contained—and in any case so full of fascinating records of native life—that it will easily stand alone on any library shelf. Finally, it must be said that the congratulations, and the thanks, of all anthropologists are due to Dr. Haddon for this ripened fruit of a well-spent life. H. S. H.

HAWAII: A Pageant of the Soil. By JEAN HOBBS. *Stanford (Calif.): University Press—London: H. Milford* (1935). 8×5½ *inches;* xviii+186 *pages; map.* 11*s* 6*d*

In spite of the unfortunate selection of the title the writer is to be congratulated on producing a valuable contribution to the later history of Hawaii over the period following the consolidation of the Group under Kamehameha I in 1795.

Dealing with the specialized aspect of native land tenure she records the break up of old native customs and the gradual introduction of European method and observances as regards ownership of land. The passing of land formerly held by chiefs to the commoners facilitated its ready sale to foreign interests and the natives so dispersed rapidly drifted to the towns, a process which hastened the extinction of the race.

There is ample evidence that this small record is the outcome of a great deal of patient research. H. G. B.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

REGIONAL PETROLOGY OF THE SOUTHERN NORTH SEA. By JAN ADRIANUS BAAK. *Wageningen: H. Veenman and Zonen* [1936]. 9½×7 *inches; 128 pages; diagram and maps*

The cry nowadays is all for more facts, and in an age of intensive research fields in which to gather them are always being discovered. The counting of pollen grains in peat is a case in point, and the analysis of sand samples from the sea bed and elsewhere proves to be another. Although the title deals with the southern North Sea only, Dr. Baak collected samples from the French coast right round to the Gironde, and as a result, he is satisfied that the sand between Calais and Normandy is of northern, but south of Normandy chiefly of local origin.

Sand is composed of light and heavy fractions. The examination of the light fractions was, after a time, deferred, as it is laborious and from the heavy mineral content a definite insight could be obtained into the composition and formation of the five petrographical provinces that were established, either separated more or less sharply, or mixed in transition zones. Geographers will be interested in the new light thrown on the vexed question of the age of the Strait of Dover. The course of the Rhine is traceable by reason of a characteristic green augite or a high percentage of saussurite. There is no doubt that for some time the course was south through the Strait—as Gregory, for rather inadequate reasons, asserted. In the last chapter the author sets out to interpret the facts, and is here on more delicate ground. He sees the Strait not open till the Riss glaciation (but in the face of a 55-m. terrace in N. France and Belgium, pre-Chellian on the Somme, can he maintain this?), at which time the North Sea was blocked by ice and accumulating water forced the opening, sweeping the deposits down into the Channel, whence they have in part been brought back on to the Dutch coast by the prevailing north-easterly current.

Dr. Baak has done good service by demonstrating that in the absence of

such major disturbances sand does not move far from its place of original deposit. The volume is clearly printed and valuable to all workers in this region. There is an extensive bibliography besides inset maps and an index to the 432 sand analyses given in the many tables. The large-scale map shows the provenance of samples and the limits of the petrographical provinces. Work is proceeding and further publications may be expected. In a new edition the rather numerous misspellings can be corrected. R. G. L.

VERHANDLUNGEN DER ACHTEN TAGUNG DER BALTISCHEN Geodätischen Kommission. August 1935. Redigiert vom Generalsekretär I. BONSDORFF. *Helsinki:* 1936. $9\frac{1}{2} \times 6$ *inches*

A recent essay review by Dr. de Graaff Hunter (*G.J.*, vol. 85, p. 465, May 1935) described and praised the labours of the Baltic Geodetic Commission. This report summarizes a further year's progress. The material presented is in quality and quantity a witness to the importance and activity of the Commission. In a world in which international cooperation in all fields is tending to vanish the persistence of this particular endeavour assumes an ever greater significance. Professor Nørlund in his presidential address recalls that "the opportunities to carry out really effective cooperation between all nations and over the whole world decrease from year to year. In these circumstances it seems to us to be of especial purpose that a few states having amongst other things in common that they surround the Baltic should cooperate in a narrowly bounded field of work."

The Commission comes this year (1936) to the end of its first span of twelve years. Much has been achieved which will influence geodetic work in other countries. This is apart from the direct success in the Commission's own sphere of work. For instance the triangulation of the Baltic circumference will be completed in 1940: base measurements are already complete, as are also the astronomical field observations. In all but two of the participating countries the gravity determinations are already adequate.

Of the tasks remaining the greatest is the adjustment of the triangulation, the computation of the coordinates, and the investigations of the geoid. All this has more than local interest. The Commission is continuously spreading its influence outwards. The connection with the great Russian arc along the 50th parallel will eventually link the system with America and possibly with India, from which a gap of only 400 km. will remain to be bridged by the end of 1937. The triangulation of the Baltic ring is bound to influence the adjustment of the German triangulation and thus the surveys of all Europe.

The reports and the papers deal for the most part with matters rather beyond the scope of this journal. But certain things are of general interest such as the confirmation in the German report of the curious phenomena revealed by observations with the modern quartz-controlled precision clocks, where the clock appears to be more accurate than time itself as given by the observed transits of heavenly bodies. Professor Kohlschütter detected a regular oscillation about which we should like to hear more. He interprets this "either as a seasonal change in astronomical refraction, some other disturbance in the determination of time, or an irregularity in the period of rotation of the earth."

Both Germany and Denmark have continued developing the static gravity meter. For the German one by von Haalck an accuracy of ± 1 mgal is claimed for the land model and ± 5 for the marine one. The Danish one by Nørgaard has only been used at sea and the accuracy is apparently about the same as that of the German one under the same conditions. Denmark is also continuing work with the Holweck-Lejay elastic pendulums, but there are clearly still

difficulties with the apparatus. These portable gravity determination instruments are of importance to geographers because they may eventually become sufficiently simple to be used to throw light on such major problems as those of coral reefs or of the Greenland ice-cap.

There is geographical interest also in the methods of seismic sounding carried out by Brockamp as part of the Danish work. It was possible to trace out the underlying sedimentary formations and in particular the depth of the deep-lying plutonic rock. Wherever this stratum approached the surface there was a corresponding positive gravity anomaly.

But even when the papers go rather more into purely geodetic matters they are all connected with practical work and are eminently readable. One could mention as of first-class importance a paper by Seidel on the influence of the refraction of the layers of air next the ground on precise levelling, or one by Krassowski drawing certain conclusions from recent work bearing on the Earth's figure. The report in fact shows how actively geodetic work is being carried out around the Baltic. M. A. S.

TABLES FOR DETERMINING THE FORM OF THE GEOID AND its Indirect Effect on Gravity. U.S.C. and G. Survey. Special Publication No. 199. By WALTER D. LAMBERT and FREDERICK W. DARLING. v+130 *pages*

The figure of the Earth is itself determined by geodetic surveying, and the process is essentially one of successive approximation. A couple of centuries ago the Earth's sea-level surface was regarded as a sphere; but about that time Newton gave reasons for expecting the surface to be an oblate spheroid and later on this truth was demonstrated observationally. During the nineteenth century and early part of the twentieth century the increasing amount of triangulation of improved accuracy allowed determinations of the axes of the spheroid to be made. Meanwhile gravity observations were utilized to evaluate the ratio of the principal axes of the spheroid; and the "flattening" found by the two methods was harmonized towards the end of last century.

During this time however the existence of anomalies in the force and direction of gravity were revealed, and much thought was expended on them. Stokes published his now famous paper "On the Variation of Gravity at the Surface of the Earth" in 1849, and showed how anomalies of gravity were related to departures of the sea-level from perfect spheroidal form. A little later Pratt and Airy gave out the hypotheses of compensation of topographical features, which now bear their names. But then such matters had not much more than academic interest, owing to paucity of observational results.

The present century has witnessed a great extension of geodetic work, and gravity observations in particular have increased largely. Now that the force of gravity can be observed at sea, the complete determination of the figure of the Earth—the form of the geoid—has become possible. Geodesists now hope to see in the next decade gravity determinations, sufficient in number and systematically distributed over ocean and continent, which will serve to portray all the main features of the geoid.

Stokes' theorem relates to a mass bounded by a level surface, which is not realized by the actual Earth. For its application to the Earth, it is necessary to remove the effect of the protuberances from the observed values of gravity. It is convenient to do this on some isostatic basis. Thus we may calculate the change in gravity resulting from moving a mountain and distributing its component matter below the geoid on the Hayford scheme. The corresponding change in geoidal level is also to be found.

To carry out such a process tables are needed. The present publication provides tables suited to this and kindred objects. It is in four parts and throughout is arranged in sympathy with Hayford's scheme of quadrature, that is, with partition of the Earth's surface into a set of zones. Each part is preceded by useful explanatory notes. Part I contains "Fundamental Tables" giving the geoidal rise and the corresponding secondary change in "g" (Bowie correction) for matter of unit density of height/depth ranging from +10 km. to −15 km.; and for isostatic purposes from −80 km. to −130 km. In Part II are tables giving the density of compensation due to land/water masses of various heights/depths, all for two assumed depths of compensation. The tables are further duplicated with height expressed alternatively in km. and feet, and depths in km. and fathoms. The tables of Parts I and II are employed to form those of Part III, "Special Bowie Reduction Tables," based on standard densities. Part IV contains tables of the function, $f(\psi)$, which occurs in Stokes' theorem, as well as of $F(\psi)=\sin\psi f(\psi)$ and $\phi(\psi)=\int_0^{\psi}F(\psi)d\psi$; and a few auxiliary tables.

The publication will save much labour to future workers. J. DE G. H.

ECONOMIC AND HISTORICAL GEOGRAPHY

THE USE AND MISUSE OF LAND. By R. MACLAGAN GORRIE. (Oxford Forestry Memoirs. No. 19.) *Oxford: Clarendon Press* 1935. 11×7½ *inches;* 80 *pages; illustrations.* 6*s*

In reviewing a work of this kind, which deals as much with policies as with facts, it is impossible to avoid social and political considerations. Indeed, the whole of Dr. Gorrie's admirable memoir is an object lesson in that interdependence of science and social welfare which, though receiving increasing recognition in many quarters, is still actively denied or only partially admitted by many influential scientists and politicians. Dr. Gorrie's final conclusions on the case in favour of public ownership and control of land are worth quoting (p. 8). "The proper agency for holding and developing land and preventing such abuses [*i.e.* overgrazing, deforestation, etc.] is a small but representative public body with sound technical advice at its disposal and sufficient powers to enforce the decisions it arrives at. Private ownership and the common use of 'waste' land has almost invariably overworked one use and neglected other possibilities, failing to develop the multiple use principle which can best serve the community as a whole." The author points out further that such abuses have been particularly severe in the village grazing and common lands in British tropical countries.

The considerations which lead to these conclusions are based on facts collected during a four months' tour of the United States with the object of studying the correlation of erosion damage and grazing in forest lands, backed up by experience in Switzerland, Haute Savoie, and Northern India. Dr. Gorrie deals in detail with the effect of such factors as overgrazing, deforestation, bad farming methods, and vegetation poisoning by factory fumes on soil erosion and describes how these problems are being dealt with on a large scale by public bodies in America. He emphasizes the necessity of handling forestry and pasture problems "as part of a well-considered land policy, in which the local need for shelter-belts, fuel and timber reserves, and grazing areas is integrated with local agricultural production, while the wider aspects of commercial timber production, water supply, flood control, game protection and recreation have also to be included." It is obvious that such a comprehensive policy can be undertaken only by centralized public bodies of the type that have

done such remarkable pioneer work in America. The alternative is the gradual wasting away of land on which the future prosperity of the community depends, the slow but inevitable death of the proverbial goose and the loss of her golden eggs. Now that the Supreme Court has nullified the A.A.A. an extension of the activities of these bodies is predicted and further valuable experience should be gained for future application in other countries.

Dr. Gorrie's memoir is clearly written and well illustrated by photographs. It brings home vividly the dangers of uncoordinated land exploitation and clearly points the common-sense way of avoiding it. J. S. L. G.

ROALD AMUNDSEN, Explorer. By CHARLES TURLEY. *London: Methuen & Co.* 1935. $7\frac{1}{2} \times 5$ *inches;* 218 *pages; illustrations and maps.* 5*s*

This is a perfectly straightforward account of the life of Roald Amundsen as an explorer. After some slight but interesting details of his youth, the succeeding chapters relate in miniature the chief events of his many expeditions. The greater part of these chapters are clearly a précis of the narratives published by Amundsen or his associates. Occasionally however there are interesting extracts from letters from Amundsen himself. The book succeeds in putting between two covers the chief events of the active life of one who will always be known as a wonderful polar traveller. To those who are hoping to be able to appreciate the man as well as the explorer the book will be disappointing, since it is the deeds rather than the man himself that are the subject of the book. The author steadfastly refuses to be drawn into more than the briefest reference to some of the great controversies in Amundsen's life, and there is very little in the book to give Amundsen's own account of the reasons for his actions.

The last few chapters of the book deal with the period when Amundsen found himself in the position of having to continue exploration in order to pay the debts of earlier work, and accordingly they show a different person from the Captain of the *Gjoa* or the leader of the expedition to the South Pole. Even in these chapters however we are given very little of the man himself and are left to draw our conclusions as to his character chiefly from his deeds. F. D.

ALEXANDRINE TINNE: Een Haagsch Meisje als Dappere Ontdekkingsreizigster en Dochter der Liefde (Bint Mtacke) in Noord-Afrika, haar Leven en Reizen. By WM. SUTHERLAND. *Amsterdam: Drukkerij Wed. G. Van* Soest 1935. $7\frac{3}{4} \times 4\frac{1}{2}$ *inches;* 80 *pages; illustrations and a map*

This little book, published in connection with the centenary of the Dutch explorer Alexandrine Petronella Francisca Tinne (1835–1869), narrates her travels in the Sudan and Algeria, and tells the story of her untimely death at the hands of robbers. It is at the same time a character-study and chiefly interesting as such, for it partly lacks those details for which the student of geography or ethnography looks. One is, for instance, somewhat disappointed when the author, speaking of a region on the upper Nile, disposes of the whole matter by remarking "They crossed a stretch of land which had a most charming aspect. The villages were well populated, and the inhabitants, headed by their chiefs, gave the party a friendly reception. A description would delay us too long, and we must confine ourselves to quoting the utterance of one of the ladies (probably Freule Tinne), 'Oh! it is a charming region which amply repays all our labours and sacrifices'." In the biographical passages the author draws a delightful pen-portrait of the explorer. He had perhaps special reason to bestow particular care on this portion of his work, for there appears to exist in Holland a certain faction which looks contemptuously on this pioneer of feminine emancipation, charging her with being unwomanly and trying to belittle her

achievements. He states in the epilogue that his book is the completion of a task begun many years ago by his mother—Marie van Eck—"herself a pioneer of feminine emancipation," and at every step he emphasizes Alexandrine's womanliness, adducing many arguments to prove his point; and on sending the book to his printer, he expresses the hope that "it will, once and for all, place the figure of Alexine in a clear light undimmed by 'legendary gossip' resulting from ignorance of Alexine's true personality."

His picture of Alexine wins the heart of the reader at the very outset. He shows her first as a mere child, sitting on the floor strewn with atlases, and "ever day-dreaming about the gaps in the map of Africa." Subsequently, we find her in the slave markets of Africa ministering to the wants of unhappy fellow creatures, and often buying them their freedom (the staff of servants in her house in Cairo included no less than eighteen negroes and negresses whom she had thus rescued). Or, again, she is seen nursing the cholera-stricken, or succouring those who have been rendered homeless in consequence of an earthquake.

The book bears traces of having been hurriedly produced, but the general effect is pleasing. The happiest inspiration of the author was perhaps to include, in all the ingenuous charm of their illiteracy, extracts from the diaries of the two murdered sailors. F. M. M.

GENERAL

A TEXTBOOK OF GEOGRAPHY. By G. C. Fry. Eighth Edition. *London: University Tutorial Press* 1936. $7\frac{1}{2} \times 5$ *inches;* xx+580 *pages; illustrations and maps.* 6*s* 6*d*

The eighth edition of this well-known text-book has been revised and enlarged and now includes a number of half-tone plates. It retains the arrangement into numbered paragraphs with varied emphasis expressed by changes in type. The revision has obviously presented difficulties. Thus the maps of the British railway systems as they were prior to 1923 are retained; the railways of Scotland are still described under the names Caledonian, North British, Glasgow and South-Western, and there is no indication of the amalgamation of the Irish lines. In other sections such outstanding recent developments as the Turk–Sib Railway are overlooked whilst an unfortunate carelessness mars much of the text and diagrams. "A railway runs from Rangoon up the Irrawaddy to Bhamo" (p. 481) is an example, since the railway does not run up the Irrawaddy valley and no railway reaches Bhamo. The P.C.G.N. spellings are used, but Kalgoorli, Krakotoa, and Hankau (whose long-projected railway to Canton is prematurely recorded) appear strange. L. D. S.

PROCEEDINGS OF THE FIFTH CONGRESS OF THE INTERnational Federation of Surveyors, London, July 1934. Edited by Mary Christy Clay. *Westminster, London: The Chartered Surveyors' Institution* [1935]. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 448 *pages; illustrations*

One of the papers included in this report defines what is covered in Great Britain by the word "surveyor." It is essential to realize that as used by the profession the implications of the word are quite different from those intended when the word is used within the covers of the *Geographical Journal*. "It is true"—to cite the paper by the Secretary of the Chartered Surveyors' Institution—"that in the early part of the last century the surveyor was primarily a measurer of land, and it is rather remarkable that even now, nearly seventy years after the foundation of the Institution, many members of the ordinary

public still seem to interpret the term in that restricted sense." The public of course has long realized that the mapping of the United Kingdom has been carried out by the Ordnance Survey; but it is another matter to demand for that reason that the primary meaning of the word "survey" should be altered. An intelligent foreigner might be excused for thinking that the English possibly used the word at home in the same sense as it used in such phrases as the Survey of India, or the Survey Department of a Crown Colony. And it is patent in this report that several distinguished visitors from foreign parts did in fact make such an assumption.

"Survey" as understood by the Chartered Surveyors' Institution is not even cadastral survey as understood on the continent, *i.e.* the delineation and registration of property for legal and taxation purposes. There is no English cadastre. Apparently certain features of the industrialization of England—railways, the development of urban areas, and the enactments enabling land to be acquired compulsorily for public services—made it necessary to bring into being a body of men well versed in the problems of the ownership and tenancy of land in England and competent to value and manage estates. These were the surveyors. So for them the mapping of property falls into an insignificant place compared with its valuation, management, and development.

A most valuable paper contributed to the Proceedings by such an English surveyor is Mr. Adkin's summary of the history of Land Tenure in Great Britain; the subject is one of great importance to any student of the social or political structure of England. A paper by a Dane, Mr. Hendriksen, makes an illuminating comparison between English and continental methods of land registration. The Committee on Methods and Instruments received several papers dealing with air and photographic surveying. One was a valuable academic discussion of accuracy and suitability by the well-known authority Dr. von Gruber of Jena; and another brought us the interesting information that the L.M.S. railway is actually employing such methods of survey. The Swiss contribution to this division reports progress in the design of tacheometric instruments and their methods of use. Another group of papers deals with quantity surveying, and a further one, including the paper by Mr. Goddard which has been drawn on at length, covers the questions of professional organization and education.

It is worth noting that several of the English papers express the wish to adopt metric units. M. A. S.

T. H. HUXLEY'S DIARY OF THE VOYAGE OF H.M.S. *RATTLESNAKE*. Edited by JULIAN HUXLEY. *London: Chatto and Windus* 1935. $9\frac{1}{2} \times 6$ *inches;* viii + 372 *pages; illustrations and map.* 15*s*

This vivid record of the experiences of a great and sensitive mind has many compensations for the lack of system imposed by the diary form. Expressions of passionate love are mixed with scientific observations on marine biology; and philosophic speculations are presented cheek by jowl with the petty irritations of daily life, just as they are by the arbitrary caprice of real experience. The many passages in which Huxley describes scenes of natural beauty are, from the literary point of view, the best parts of the diary. The directness of his descriptive style reproduces that immediacy of perception which characterizes the first-hand appreciation of the beautiful in nature. But there was much of ugliness as well as of beauty for Huxley in this voyage. The accounts of his physical and spiritual trials—the cramped quarters, the poor food, the intolerable climatic conditions, and above all a constantly recurring doubt of his own ability, accentuated by his feeling of responsibility towards his fiancée; all these make clear the difficulties with which he had to contend.

Psychologically the four years' voyage as assistant-surgeon on the *Rattlesnake* was important for Huxley in two ways. In the first place it was his first direct contact with the scientific realities whose study was to be his life's work. (A lucid explanatory chapter, contributed by the Editor, makes the scientific references intelligible to the layman.) Secondly the *Rattlesnake* made Sydney her base during her series of cruises, and here Huxley met and became engaged to Henrietta Heathorn, whom he subsequently married after years of separation and struggle for reunion.

Her influence over him may perhaps explain the greater predominance, in the final pages of the diary, of something which can only be described by that much abused phrase "human interest." While he was away on one of his cruises she kept a diary, which he read and re-read on his homeward voyage. It contains expressions of her deep devotion to him, together with accounts of "domestic incidents, visits to and from friends, picnics, shopping excursions into Sydney, and the like." Perhaps this record, with the lively sociability which it betrays, was the most valuable reading Huxley did on the whole voyage, and accounts for his increased interest in persons as opposed to things. To mention only two examples, he is concerned with a doctor's responsibility towards his patient, and we find him after nearly four years effecting a belated *rapprochement* with his senior, Dr. Thomson. R. P.

MYTHOS UND KULT DER STEINZEIT. By J. WINTHUIS. *Stuttgart: Strecker und Schröder* 1935. $9\frac{1}{2} \times 6\frac{1}{2}$ *inches;* xvi+294 *pages. M.*14

As Dr. Winthuis is not very well known in this country it may be of use to explain the position he takes up. He uses the Central Australians as our nearest approach to primitive man and gives much weight to observations of Strehlow and of Cathrein, as well as of Spencer and Gillen. But he thinks that all these workers fell short through not recognizing that the language of the myth, ritual, and song of these people is not to be interpreted literally. He believes it is all metaphorical and that the metaphors chiefly relate to the relation of sex-activities to the creation of living beings, whether paternity is understood or the man's part is supposed to be the appropriate magic to secure a birth. He thinks that myth, ritual, and ceremonial song are all a unified scheme among these peoples, that they have as a fundamental idea a belief in one god who combines the two sexes and who is closely linked up with the notion of the immortality of the soul, a notion that weaves itself into the ethical system. The idea of the one god, he argues, is older and more fundamental than any polytheistic fancies, or animism, or fetishism, or totemism, but he is far from accepting Father Schmidt's views.

One may grant that figurative language and sexual symbolism no doubt play a very large part among lowly peoples. One may find it less easy to agree that the Central Australians give us a special approach to the primeval, or that the present author's interpretations of what he and others have heard are more authoritative than the alternative ones. The claim that a primitive androgynous deity is a widespread feature of human thought is hardly established. It is very difficult to estimate the meanings of statements of peoples across the gulf in culture and language-type that separates us from the Central Australians.

H. J. F.

THE MONTHLY RECORD

MEDALS AND AWARDS, 1936

His Majesty the King has approved the award of the Royal Medals as follows: the *Founder's Medal* to Mr. G. W. Murray, Director of Desert Surveys, Egypt, for his long-continued explorations and surveys in the deserts of Sinai and Eastern Egypt; for his studies of Badawin tribes, and his unstinted help to desert expeditions; the *Patron's Medal* to Major R. E. Cheesman, C.B.E., for valuable service to geography during nine years' residence in N.W. Ethiopia including reconnaissance and surveys of the course of the Blue Nile and exploration of Lake Tana and its Islands. The Council have awarded the *Victoria Medal* to Dr. Stanley Kemp, F.R.S., for his work in surveys of the Southern Ocean; the *Murchison Grant* to Mr. Michael Leahy, for his explorations of Central New Guinea; the *Back Grant* to Muhammad Ayub Khan, for his surveys on three expeditions under the leadership of Sir Aurel Stein in East Persia, 1931–34; the *Cuthbert Peek Grant* to Mr. T. H. Harrisson, to assist him in his proposed expedition to New Guinea; the *Gill Memorial* to Lieutenant A. L. Nelson, R.N.R., for his Charts of the South Sandwich Group, South Orkneys, and South Shetlands.

GEOGRAPHY OF CENTRAL QUEBEC

In continuation of his researches into the geography of Canada, Professor Raoul Blanchard has turned his attention to the centre of the Province of Quebec. The first of three studies, which deals with the St. Lawrence region between Quebec and Montreal, is published in the *Revue de Géographie Alpine* (vol. XXIV, pt. i, 1936). This monograph, based upon extensive field-work, in addition to the tentative interpretations of its physical history advanced, provides an up-to-date picture of conditions in this somewhat neglected area. Professor Blanchard argues that the St. Lawrence platform gently inclined from north-east to south-west, and sharply distinguished from the Laurentian heights to the north and the Appalachian folds of the south-east, is an erosion surface, not an area of subsidence. This surface, cut by the pre-glacial river, was then warped and tilted, the St. Lawrence then re-cutting its present bed. The features of the present topography are further due to the glacier which, by scooping out a great basin, now represented by Lake St. Peter, determined the main features of the hydrographical system, and to the "mer Champlain," which laid down to the Quaternary deposits of fine sands and clays. The distribution of the latter is responsible for the patchwork of varied and independent natural regions within the general physical unity. The writer distinguishes four main divisions: the region around Lake St. Peter, of low, flat, clay lands, potentially a rich agricultural area but as yet not developed intensively; the "high platform" between the river and the broken topography to the south, its development hampered by poor soil and relative isolation, and still partly uninhabited; the "Bord de l'Eau," the strip north of the river, formerly a busy economic area, but now stranded through the exhaustion of minerals and timber; the poor sandy areas of the delta of the St. Maurice. In the latter has grown up the chief industrial centre of the region, Three Rivers, owing its prosperity to its position on the sole important route to the north, the St. Maurice River, by which also it secures the timber upon which its paper industries are based. The St. Lawrence has in the past been the one link holding these areas together, but it is ceasing to perform this function—the shipping passing straight upstream to Montreal. The urban centres of Montreal and

Quebec have also interfered with their development, and attract the rural population which cannot support itself by farming. Professor Blanchard points out that land similar to the Lake St. Peter area would in France and Italy be supporting a much greater density: the difference is due to the demand for a high standard of living, lack of employment for the labourers during the winters, and the system of farming. The less favoured areas, for example the "high platform," fail to support a density of 10 per km². As elsewhere in Canada, the problem in this real "heart of French Canada" is the development of "a more rational exploitation of the soil."

INTERNATIONAL COMMISSION OF SNOW

The International Union of Geodesy and Geophysics meets this year in Edinburgh from September 17 to September 26, and one of its constituent associations, that of Hydrology, has a new sub-commission named the International Commission of Snow, which then meets for the first time under the Presidency of Professor J. E. Church, of Nevada University, U.S.A. The International Commission of Snow proposes to meet at Edinburgh on September 14–16 in advance of the meetings of the Union. The Chairman of the British group taking part in the work of this Commission is Mr. Gerald Seligman, of Warren Close, Coombe Hill Road, Kingston Hill, Surrey, who would be glad to get in touch with any Fellows of the Society who are specially interested in the problems of snow.

DATING OF PUEBLO RUINS BY ANNUAL TREE-RINGS

The National Geographic Society have begun a series of special publications dealing with their exploration of the prehistoric pueblo sites of the south-west. The first of these, by Dr. A. E. Douglass—'Dating Pueblo Bonito and other ruins of the south-west'—describes concisely the method of dating by means of annual tree-rings, and the results thus obtained. The method depends upon the identification of irregular successions of large and small rings in beams and wood obtained from the archaeological sites. Examination of many sections of trees grown on the Colorado plateau west of the Rio Grande valley shows that this area forms a climatic unit as regards tree growth. These successions of rings, produced by the influence of rainfall variation upon tree growth, have individual characteristics which are never exactly repeated through many centuries. It is possible even to identify accurately the rings which grew in a particular year. By working back therefore from sections of recently felled trees to those of successive overlapping sections it has been possible to construct a time scale extending back many centuries, from which the date of the timber used in buildings can be determined. Dr. Douglass, before undertaking this research, had a modern ring sequence dating back to A.D. 1300. As the result of the first two expeditions a prehistoric sequence covering 585 years was established. A large and distinctive annual growth ring in this sequence was given the hypothetical date 500, thus establishing a relative chronology. The problem of the third expedition was to close the gap between these two systems and thus to determine the actual date represented by "500." This was finally done by the excavation of a beam still in place in the ruins at Showlow—or, more accurately, this beam revealed that the two systems actually overlapped, but that the great drought, responsible for the lack of timber from this period had resulted in a ring record difficult to decipher. The hypothetical date was found to correspond with the year 1087, and a continuous record from 700–1929 was established. From this it appears that work upon Pueblo Bonito was begun about A.D. 919. Oraibi, the oldest continuously inhabited settlement in the

United States, dates from about 1370. Dr. Douglas gives a complete list of the dates obtained for 400 specimens of timber from forty-five different ruins, with photographs of the sections comprising the continuous series.

THE EARTHQUAKES OF MOUNT ETNA

A historical review of the major earthquakes in the vicinity of Mount Etna, entitled 'I Terremoti Etnei,' prepared by G. Imbò as a preliminary to a more detailed investigation, has been published by the Italian Commission for the Study of Calamities (vol. 5, pt. 1, 1935). After brief references to violent shocks in previous centuries, the chronicle proper, recording both earthquakes and eruptions, extends from 1285 to 1933, being more complete after 1852. For a number of the later shocks maps are produced showing the iso-seismic lines. Some general conclusions are drawn, and these are embodied in a map of the "seismo-tectonic zones." Three such zones of special liability to earthquakes are indicated as spreading outwards from near the summit of the volcano to a distance of 10 to 15 kilometres, the largest southwards towards Catania, another northwards, and the smallest westward. In the southern zone seven positions where epicentres cluster lie in the lower habitated country, but in the others the epicentres migrate too much to be localized thus.

The eastern slopes of the mountain are comparatively free from shocks at the higher levels, but lower down, adjacent to the coast, a fourth zone of crustal weakness appears. The seismo-tectonic lines show that here the shocks tend to occur along certain alignments, identified with lines of fracture, but the author explains that they show little correspondence with Hobbs's lines for the same area drawn simply by connecting up centres of damage.

In the three zones on the mountain flanks eruptive cones and fissures are more numerous than elsewhere, especially in the southern zone, where they extend to the lowest levels. Though the correspondence might be expected, it is perhaps closer than could have been assumed. The violent shocks are usually accompanied by eruptions, explosive or effusive, from the terminal crater, and are followed at very varying intervals by lateral eruptions. It is hoped to extend the investigations to the minor shocks, so that it may be possible to determine the areas in which building should be avoided.

Shocks are frequently felt on Etna from disturbances originating outside the area, as far off as Greece. As regards the shocks originating nearer at hand, a correspondence has been observed between disturbances in Calabria and eruptions of Etna. This may only be fortuitous: a definite connection however has been established between the eruptions and earthquakes in the Val di Noto in the extreme south of Sicily. This connection is attributed to slow crustal movements.

DROUGHT IN LIBYA

In a publication of the Italian Commission for the Study of Calamities (vol. 4, pt. 2, 1935) R. Fantoli describes in detail the highly unfavourable rainfall regime which has hampered the settlement and development of the Italian colony of Libya. On the elevated plateau to the east of Benghazi the mean annual rainfall reaches 20 inches, and in the vicinity of Tripoli 16 inches; but on the low shores of the Gulf of Sidra it does not exceed 8 inches, falling off to 1 inch 50 kilometres inland. Nowhere is it appreciable south of the 31st parallel of latitude. Only a small proportion of the winter rainfall is due to the Mediterranean depressions, which take a course too far to the north, the greater proportion being caused by the relief of the land in relation to on-shore winds. The rainfall consequently is not only local, but the area in which it falls is liable to

vary from year to year with changes in the direction of the winds. This prevents the correlation of the rainfalls at neighbouring stations, as can often be done in regions with more regular rain.

The conditions of the rainfall are unsatisfactory from every point of view: the rain is scanty, limited to a portion of the year, very irregular from year to year, from place to place, and in its monthly distribution. The last consideration —the monthly distribution—is specially important for agriculture. In a favourable agricultural year 20 per cent. of the total falls in October and November, 20 per cent. in December and January, and 40 per cent. in February and March. This distribution has occurred at Tripoli only in six years out of forty, and too frequently the rains have been concentrated in December and January, the period of highest average rainfall. The critical time for cereals is March, and, on the high plateau, April or early May, when damage is liable to be done by hot southerly desert winds known as *ghibli*.

The study is designed as a basis of discussion for questions relating to the development of the colony, and to the application of relief measures for drought-stricken areas in accordance. It is pointed out that the specification of the circumstances justifying public assistance is somewhat difficult in a country where famines may arise not so much from an outstandingly dry year as from the cumulative effects of a number of years with rainfall below normal.

OBITUARY

FIELD MARSHAL THE VISCOUNT ALLENBY OF MEGIDDO

Of the great Field Marshal's services to the State and to the cause of the Allies in the Great War it is superfluous to speak here. His fame as one of the great British commanders is world wide, and the place of his greatest triumph made part of the title by which he was ennobled in 1919. For six years after the war he was High Commissioner for Egypt, and soon after his return to England he was elected to the Society, becoming a Member of Council in 1927, a Vice-President in the following year, and reverting to the Council in 1932. For a period of each year it was his habit to visit with Lady Allenby a British Dominion overseas or to make a long journey in some foreign possession, as the Netherlands Indies ; and only lately he returned from several months in South America. When he was at home he was constant in his attendances at the Council and the meetings of the Society, and was present at the meeting of May 4. After the meeting, in conversation with the President, he mentioned appreciatively the great interest which his association with the work of the Society afforded him. It was but a few days later he died suddenly worn out, as so many of his greatest comrades have done : and it is sad that we shall see no more his spendid figure at our gatherings. On May 19 his ashes were laid in the Warrior's Chapel in Westminster Abbey, after a great military service at which the Society was represented by the President.

JAMES HUSTON EDGAR

Mr. J. H. Edgar, who died at Tatsienlu on March 23 last, at the age of sixty-four, had been a pioneer missionary of the China Inland Mission on the China–Tibet border for thirty years. He was much interested in the mountains about Tatsienlu, and particularly in the Kung Ka range which culminates in the peak,

Minya Gonka (or Bo Gang Kar, as Edgar wrote it), of approximately 25,000 feet. Several travellers since the time of Gill and the Szechenyi expedition had referred, often very confusingly, to the existence of this peak, but Edgar was among the first to study the topography in detail. His first paper was published in the *Journal* of the West China Border Research Society for 1922, and he later contributed an article to the *Geographical Journal* for September 1933, on earlier travellers in the region and on the nomenclature. He also gave considerable assistance to later expeditions, including the Roosevelt party, Professor Arnold Heim, and the American climbers, Messrs. Terris Moore and R. Burdsall, who made the first ascent of Minya Gonka in 1932.

From 1902 onwards Mr. Edgar made a number of journeys along the Tibetan frontier. One of these was made in 1911 from Batang to Menkong on the Salween in the company of Col. F. M. Bailey, who afterwards described him as a keen traveller and observer, and one "whose familiarity with the conditions on this frontier is unsurpassed." Mr. Edgar's interests were wide, and one of his contributions to science is the large collection of artefacts which he presented to the Archaeological Museum of the West China Union University. He was also a founder, and for many years Honorary President, of the West China Border Research Society, to the *Journal* of which he contributed many papers.

Mr. Edgar was of Scottish border stock, and before going to China had travelled extensively in New Zealand and Australia. He had been a Fellow of our Society since 1909.

For much of the above information we are indebted to Mr. A. J. Brace, of Changtu.

MEETINGS: SESSION 1935–36

Sixteenth Evening Meeting, 8 June 1936. The President in the Chair

Elections: Lord Aberconway, C.B.E., M.A.; The Dowager Viscountess Allenby; Miss Alicia Irene Amsden; Frederick James Fitzmaurice Barrington; Frank Albert Bex, A.L.A.A.; Miss Bertha Mary Broadhurst, B.SC.; David Roden Buxton; William Ernest Chamberlain; A. Cheriyan; The Reverend John Rumley Collins; William W. Conrad; Cecil Paines Davis; Norman Douglass; John Farley; Miss Constance L. H. Geary, M.A.; Frank George, I.C.S.; Miss Ruth Grinham; Quintin Edward Gurney; The Hon. C. W. Baillie-Hamilton; The Reverend Reginald Hewitson, B.D.; Andrew Newport Coutts Horne, F.R.MET.SOC.; Dr. Julian Sorell Huxley; Frederick Joseph Pryce-Jenkin; Herbert William Henry King, B.A.; E. J. L. Lambert; L. J. McMillan; Arthur Frank Tregarthen Magor; D'Arcy John Desmond Mander; Major H. P. Morrison, M.C.; Lady Louis Mountbatten; Philip Dan Orcutt; The Reverend Thomas Arthur Osborne, M.A., B.D., LL.B., J.D.; John Dobree Pascoe; Mechelin Joel Langley Rogers; Randal H. V. Smith; Miss Freya Stark; Geoffrey John St. Jermain Steadman; Vidya Bhushan "Vibhu"; Miss Fannie Waldron

Paper: The Quetta Earthquake. By Mr. C. P. Skrine

Eighth Afternoon Meeting, 15 June 1936. The President in the Chair

Paper: Population Maps of Bengal. By Dr. Arthur Geddes